JOURNAL OF THE A·I·E·E·

JUNE 1928

PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

SUMMER CONVENTION, DENVER, JUNE 25-29

DENVER SUMMER CONVENTION 1928

SCENIC AND ENGINEERING FEATURES

1.—Grave of Col. William F. Cody (Buffalo Bill) on Lookout Mountain
2.—Valmont Plant of Public Service Company of Colo. (45,000-kw. Turbine)
3.—Firing Aisle—Valmont Plant Boiler Room
4.—Trout Fishing in Bear Creek, Colorado foothills, 25 mi. west of Denver
5.—Engineers' Lariat Trail—A giant lasso on Denver's 65-mi. auto trip through the city's mountain parks
6.—Pulverizing and Coal Handling Plant—Valmont Plant
7.—Tower No. 746 on top of Argentine Pass
8.—View of Denver
9.—Argentine Pass Transposition Fixture Denver-Salt Lake line (4000 strand conductors)
10.—25,000-kw. Turbine, installed 1926 at Valmont Plant (foreground), with 20,000-kw. Turbine installed 1924 in background
11.—Switchboard—Valmont Plant

JOURNAL

OF THE

American Institute of Electrical Engineers

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33 West 39th Street, New York

PUBLICATION COMMITTEE

E. B. Meyer, *Chairman*, H. P. Charlesworth, F. L. Hutchinson, Donald McNicol, L. F. Morehouse

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Institute and Related Activities—*Continued*

MEETINGS

of the

American Institute of Electrical Engineers

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PACIFIC COAST CONVENTION, Spokane, Washington (August 28-31, 1928)

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MEETINGS OF OTHER SOCIETIES

Institute of Radio Engineers, Engineering Societies Bldg., New York, N. Y., June 6, 1928

National Electric Light Association, Atlantic City, June 4-8, 1928

Pacific Coast Division, Hotel Huntington, Pasadena, Calif., June 12-15, 1928

Northwest Division, Portland, Oregon, June 19-22, 1928

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

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Vol. XLVII JUNE, 1928 Number 6

The Summer Convention at Denver, Colo.

For many years the A. I. E. E. Summer Conventions have presented programs in which the technical features and the entertainment and social features have been pretty evenly balanced, and the program of the Denver Convention, printed in this issue, is no exception to this rule. The advantage of acquaintantship and social intercourse among the membership is obvious and was recognized when the Board of Directors many years ago ruled that the technical sessions at Summer Conventions should be confined to the mornings, leaving the balance of each day for entertainment and amusements.

No better selection of a convention place than Denver could be made for affording an opportunity to combine business and pleasure. Surrounded by some of the most celebrated scenic resorts in the country, those who attend the Denver convention will be able, with but little additional travel and expense, to combine the benefits of an interesting technical convention with a delightful vacation excursion.

Progress of the New Publication Policy

Five months have elapsed since the changes in the form of Institute publications, authorized by the Board of Directors last December, have been in effect, and sufficient experience has been gained in this period of time to indicate that the present plans are functioning with a gratifying degree of efficiency. We refer of course to the four page abridgments in the JOURNAL, the free distribution of complete pamphlet copies, and the QUARTERLY TRANSACTIONS. For the first half of 1928 we are publishing a greater volume of papers than in any previous similar period in the history of the Institute, but in spite of this increase in the amount of material published the JOURNAL has been held down to a reasonable size, all demands for complete copies have been met, and no papers have been crowded out of the TRANSACTIONS for lack of space; and this has been accomplished without exceeding the pro rata share to date of our publication appropriation.

The demand for advance copies has reached about four hundred per month, which is somewhat less than was anticipated. If this number really indicates the number of members interested in receiving copies of complete papers the use of the shorter abridgments printed in the JOURNAL is certainly justified. The difference in cost of supplying a few hundred pamphlets, and of printing the complete papers in a 25,000 edition of the JOURNAL is readily apparent.

One decided advantage exists in the case of the QUARTERLY TRANSACTIONS, however, and that is the promptness with which the complete papers and discussions can be published. The second QUARTERLY which is now being mailed contains the entire program of this year's Winter Convention except one paper by foreign authors. This volume is available for reference purposes less than four months after the close of the convention, whereas, in case of the annual volume, which has generally been distributed in September of the following year, the same Winter Convention program would not have been available until nineteen months after the convention.

Some Leaders of the A. I. E. E.

William Slocum Barstow, Vice-President of the Institute 1903-1905 and one of its Managers for three successive years immediately preceding that period, was born in Brooklyn, New York, February 1866. He was graduated from the Adelphi Academy in 1883 and from Columbia University in 1887, with a degree of B. A. That same year, he entered the employ of the Edison Machine Works at Schenectady, but resigned in 1889 to connect with the Edison Electric Illuminating Company of Brooklyn, becoming successively its assistant superintendent, superintendent, chief engineer and, ultimately, general manager in 1901. In this capacity, Mr. Barstow was very active in the engineering field and one of the leaders in the expansion of the industry, devising apparatus and methods for meeting the demands of rapidly growing central station systems. For many years he served as secretary, then as treasurer and a member of the executive committee of the Association of Edison Illuminating Companies. He also was a prolific contributor to technical literature, chiefly in the field of illumination and papers before the Association of Edison Illuminating Companies.

He was chosen a member of the U. S. Government Committee on the Super-Power System for the Eastern States and of the Jury of Awards of the Pan-American Exposition at Buffalo. He has served also on many other committees of commercial and technical purpose. Mr. Barstow was a leader in appreciating the application of the storage battery as an invaluable auxiliary to securing the maximum guarantee of continuity of service in Edison d-c. systems of distribution; in fact, a number of patents for storage battery boosters are

to his credit, as are a number of patents for a two-rate meter, clock switches, etc., etc.

Much of the pioneer work in the development of the present system of power generation in large central stations, high-tension alternating current, transmission by high-tension cables to substations, and the conversion and transformation by transformers and converters to direct current for application in the low-tension d-c. distributing system was accomplished by him.

Resigning from the Brooklyn Edison Company, Mr. Barstow entered into a consulting practise, later organizing W. S. Barstow & Company, engineers and financial and operating managers of public utilities, with Mr. Barstow, a farsighted and successful executive, at its head. He is also president of the General Gas & Electric Corporation and fourteen of its subsidiary operating properties, as well as a director of many other representative corporations.

Mr. Barstow is active in civic fields as well, devoting much of his attention outside of business and personal interests to local government affairs as mayor of the Village of Kings Point, Great Neck, New York.

Michigan's First Lighted Airway

Michigan's first lighted airway—from Detroit to Cleveland—is under construction and should be ready for operation within a short time according to a recent announcement made by the Michigan Public Utility Information Bureau at Ann Arbor. It is the initial section of a system of beacon-marked aerial pathways that will within a few years, it is expected, connect all the leading cities of the lower part of the state with each other and with the remainder of the country.

The lighted airway runs from Toledo to Detroit by way of Monroe. Installation of the beacons is under the direction of the Airways Division of the Bureau of Lighthouses, U. S. Department of Commerce. When put into service they will be maintained by the Bureau of Lighthouses, with current furnished to three of them by The Detroit Edison Company, to one by the Toledo Edison Company, and to one by the Ford Company.

The airway will conform to the standard set by the Department of Commerce, which calls for lighted intermediate landing fields at 30 miles intervals and beacon lights at 10 miles intervals between these fields. The intermediate landing field is being established one mile west of Monroe. It will have a beacon and about 30 green lights to mark the limits of the field. Lights probably will be placed also, on obstructions near the field. One beacon light will be on the Newport road one-half mile from Telegraph Road, one on the Ford water tank at Rockwood, and one near Eureka and Telegraph Roads. The Detroit end of the airway will be the Ford Airport at Dearborn.

The beacons and field, it is announced by the Airways Division of the Bureau of Lighthouses, will be kept lighted from dusk to dawn every night of the year "to the end that night flying may be accomplished with maximum safety to pilots and passengers." The airway is established under the Air Commerce Act for encouraging and fostering commercial aviation. This act provides, among other things, for the construction and maintenance by the Department of Commerce of a system of airways, which, when completed, will link together all the principal cities of the United States in a network of aerial routes.

Various cities of Michigan are looking forward to the time when the lighted airways will be extended to them. Consumers Power Company has been asked to consider the matter of beacon and landing lights for airports at Jackson, Saginaw, and Muskegon. Preparations along this line will be greatly encouraged by the actual establishment of Michigan's first lighted airway.—*Transactions I. E. S.*

A Correction

To the Editor:

In the May number of the Institute JOURNAL you have published under the head of "Leaders," a sketch of my activities, at which I am much gratified. However a curious mistake has occurred as to my birthplace. It is given as Victoria, Canada, whereas it should have been Victor, Ontario County, New York. I am proud of having been born in the greatest State of the Union of a great nation and it is a distinction I wish to preserve.

The account speaks of my six generations of New England stock. It might be of added interest that I am descended from John Foskett, who came from Bristol, England, to Charlestown, Mass. about 1653. His great grandson John Foskett, Jr. resided in Westminister, Mass. from 1755 to 1796 and was active in the township's affairs prior to and during the Revolution. His son Samuel of Colerain, Mass., had the family name changed by Act of the Legislature of the State of Massachusetts in 1820 from Foskett to Bradley.

My mother was the eldest daughter of H. V. B. Schenck, the son of Capt. John Schenck, of the Revolution, and the great grandson of Roloef Schenck of Flatlands in South Brooklyn. He built of ship timbers the house which is said to be the oldest house in the state of New York. Roloef Schenck came to the shores of Jamaica Bay about 1650, and afterwards was magistrate of New Amersfurst now Flatlands.

Yours truly,

CHARLES SCHENCK BRADLEY

May 21, 1928.

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Superimposed High-Frequency Currents for Circuit-Breaker Control

BY LEON R. LUDWIG[1]

Applicant for Membership

Synopsis.—*On railway or polyphase power systems having a multiplicity of parallel lines, there are unique possibilities in superimposing on the lines a frequency of the magnitude of 500 cycles, (together with the consequent apparatus), to gain selective protection under all fault conditions. The principle suggested is to measure the impedance of the power system with 500-cycle current and high-frequency relays, so placed that under abnormal conditions, the impedance of a faulty line, as measured by the relays protecting that line only, is sufficiently low to cause circuit breaker operation.*

The advantages of such a protective system would be:

1. Perfect selectivity between parallel power lines, such that a faulty line may be isolated without disturbing other lines.

2. Instantaneous operation.

3. Simultaneous operation of protective breakers at the two ends of a faulty line.

4. Protection of the line against short circuits or faults, but the avoidance of breaker operation on heavy overloads when the current rush may be greater than at short circuit.

5. A measure of the continuance of a fault, permitting automatic reclosing of circuit-breakers.

This super-frequency control system brings to light a number of refreshing conceptions, and while it is not completely developed at this time, sufficient experimental work has been done to warrant presenting the results as a matter of technical interest.

The Circuit-Breaker Control Problem

Any relay or other type of apparatus called on to automatically control circuit-breakers must meet an increasing number of rigorous qualifications. In addition to causing the breaker to operate if excessive currents arise in the system to which it is applied, there are a number of other requirements which are essential, or desirable, all or some of which must be fulfilled, depending on the system.

First, the system to be protected may consist of parallel feeders, any of which is liable to a fault. Should one of the parallel feeders become faulty at any point, it is essential that this feeder be disconnected from the system by opening circuit-breakers at both of its terminals, but parallel feeders should remain undisturbed. This desirability of perfect selectivity between parallel conductors may, if the fault occurs near one terminal, tax the ordinary relay beyond its limit of differentiation.

An increasingly important requisite is the high speed of both relay and circuit-breaker operation. On power systems, the ability of protective apparatus to rapidly isolate a fault is an important asset in maintaining stability. The dynamic stability may be greatly increased if the time required to remove a fault is somewhat less than that required for synchronous machinery to appreciably shift its phase angle. In case of nearby parallel telephone lines, telephone interference may dictate rapid isolation.

On many systems having a widely divergent load demand, heavy-load currents may exceed short-circuit currents if the short circuit occurs with the minimum of generating capacity connected to the line. The control equipment must act to isolate the short circuit, but should not open the loaded line, a condition which precludes the use of plain overload relays.

There are other desirable features of relaying systems, three of which may be mentioned. Circuit breakers are frequently tripped to temporary faults, in which case, if the relay could determine the nature of the fault, the breaker might be again closed and normal conditions restored without the need of an operator. Automatic reclosing would be particularly advantageous if, with the circuit-breaker open, the relay could determine whether or not it might safely be reclosed. From the standpoint of telephone interference, a further requirement is the simultaneous operation of the circuit-breakers which are to open, or the avoidance of "cascade" operation. The third feature is a relay system which could be set and tested for proper operation without the necessity of actually placing a short circuit on the power system.

A combination of the above problems has so strained the usual concepts of relay procedure that an entirely new basis of circuit-breaker control is desirable and may be found in the application of a superimposed high-frequency current system. The purpose of the new system is therefore to extend the limitations naturally imposed by the use of normal frequency relays.

Description of the System

The 500-cycle system consists essentially of a source of high-frequency power, a means for introducing it into the lines to be protected, means for obtaining selectivity in case of parallel lines, and the circuit breaker operating relays. The system is equally applicable to a single-phase railway system or a polyphase power system. An application to a single-phase system may be described first for simplicity. In Fig. 1 is shown a grounded single-phase system, which may be a railway network. There are two parallel contact lines supplied with power from transformers located in three substations. A circuit breaker is placed in each end of each contact line.

The 500-cycle current is introduced into the system by a connection from the generator or power source to the ground side of the main transformer. The other

1. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928.

terminal of the power source, which is usually a small high-frequency synchronous generator, is connected to the ground. A high-frequency power source is necessary at each point in the network where power current of normal frequency is supplied. To prevent the high-frequency generator from being short-circuited by this connection, a resonant device consisting of a condenser in parallel with an inductance is placed in the main power circuit between the point of connection of the generator and ground. The condenser and inductance are each designed to have the same reactance at the high frequency, and therefore if their resistance is low, their combined impedance will be very high. Currents of normal frequency pass easily through the inductance, which has in itself a very small impedance. The parallel circuit may be referred to as a "blocking shunt."

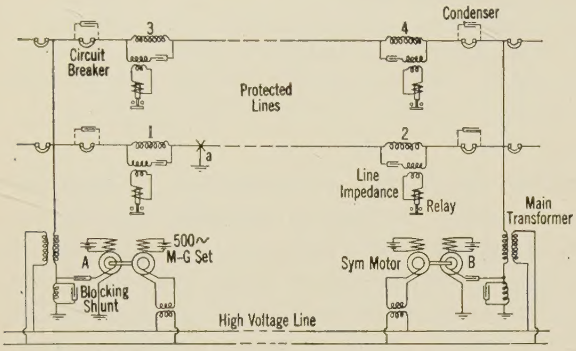

Fig. 1—Protective System Applied to a Single-Phase Network

In order to gain selectivity between parallel lines, a device similar to the blocking shunt, though very much smaller, is placed in each end of each line. Its function is purely as a line-impedance at the high frequency, with the advantage that considerable impedance may be obtained by the use of a very small reactor in this way. A high-frequency current will circulate in the parallel line-impedance which is proportional to the high-frequency current in the line. The relay itself may therefore be connected to a current transformer placed in the condenser branch of the line-impedance. The condenser will carry very little of the power current, which means that the relay will function solely on high-frequency current proportional to that in the line.

Description of Operation

Normally, with no fault or load on the contact lines, the generated voltages of the high-frequency machines are equal and opposed. These machines will synchronize and there will be no appreciable current flowing in the contact lines. To further aid in keeping the voltages opposed, the generators are driven by normal-frequency synchronous motors, which will maintain an almost constant phase position.

If a ground occurs at (a) on one of the lines, high-frequency current will flow from the generator through the main transformer to the contact line, then to ground through the fault, and return. An appreciable current will therefore circulate in the resonant line impedance (1) and (2), sufficient in magnitude to trip the corresponding relay. Some current will also flow from the generator B through the line (3-4), but this current will be less in magnitude because it must pass through three line-impedances instead of one as in the former case. Then the current in the parallel line will not be sufficient to trip the relays at (3) and (4). For similar reasons, the remaining relays in the adjacent lines will not be tripped.

In case some form of load is connected to one of the contact lines,—a locomotive for example,—high-frequency current will flow to ground through the load, but will not be sufficiently great to trip any of the relays because of the load impedance. It is fundamental that the high-frequency current always provides a means of measuring impedance regardless of the network. Normal speeds of rotating machinery are so much below the high-frequency synchronous speed that practically no counter-voltage is generated at this high frequency. It is also usually the case that the blocked impedance of the load is high in comparison with line impedances, which means that there is a good margin of differentiation between heavy loads and short circuits. In brief, the high-frequency system may be looked upon as a network equivalent to that of the normal frequency except that all normal frequency rotating apparatus may be considered as blocked.

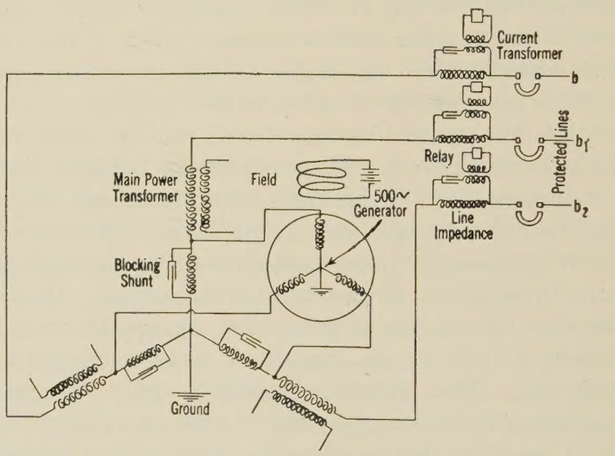

Fig. 2—Protective System Applied to a Three-Phase Network

Polyphase Application

The means of using this apparatus on a polyphase system is shown in Fig. 2. The high-frequency generators must now be polyphase. Their current may be introduced in the neutral side of the main transformer winding, three of the blocking shunts per power source being required. It is assumed that the main transformers are connected in star with a grounded neutral. Otherwise, the method of connection will be given later. If there are parallel lines, line impedances must be used as before. The principle of operation is

the same; namely, that the high frequency is introduced and the line impedances are so placed that the impedance measured by a given relay is the correct impedance to cause that relay to trip, provided there is a fault on the line it protects. By tracing the path of current in the diagram, it can be seen that a short circuit between lines $(b_1 - b)$ will cause a relay-actuating current to flow.

Discussion of Special Problems

The system depends so largely for its successful operation upon the parallel resonant circuits that special mention of their properties will be made. If the condenser and reactance are resonant at the chosen high frequency,—500 cycles for example,—then at 25 cycles the reactor will have one-twentieth of its high-frequency reactance. The condensive reactance will be increased twenty times at normal frequency, or 1/400 of the load current will pass through the condenser. The reactor must be designed, therefore, to carry the

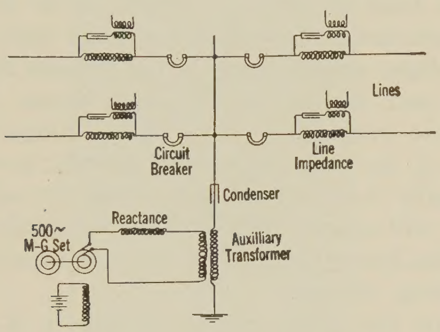

Fig. 3—Special Method of Introducing Auxiliary Current Into a Line

load current. The impedance of the parallel device is very nearly $Z = \dfrac{x^2}{r}$ in which x is the reactance of either the condenser or reactor and r is the resistance of both. Practically, if x is increased beyond a certain point, r must be increased directly with it, or the impedance will vary as the first power of the reactance.

It is easy to obtain an impedance of a few hundred ohms, which is sufficient for the blocking shunts, with a comparatively small reactor and a single condenser unit. The line impedances require about 40 ohms, which is very easily obtained.

In certain networks the blocking shunts may serve another function than previously explained. It may be desirable to subdivide a complicated system into a number of simple high-frequency systems in order to measure the impedance of the simplified systems. The ability to do this by inserting the blocking shunts at predetermined division points, is very important because the most involved network may be resolved into a number of small networks for the purpose of facilitating high-frequency relay protection.

There is a special problem also in getting the proper connection of the high-frequency power to the protected lines. To avoid insulation to ground of the high-frequency apparatus the connection in Figs. 1 and 2 is made on the low side of the transformer. This method is feasible because the reactance of a large power transformer is low. The transformer reactance is, in fact, helpful because the high-frequency system should be laid out in such a way that short circuits on the protected lines are loads, not short circuits, upon the protective system. In some cases, however, there are circuit breakers to be controlled at points where no transformers are used. In this event, the procedure is to make the connection as in Fig. 3. The condenser in the specially provided tap has sufficient reactance to prevent the normal-frequency currents from flowing to ground. The transformer reactance, plus the additional reactance inserted in the generator circuit, is sufficient to overcome the high-frequency reactance of the condenser, and the superimposed current may easily enter the lines. The transformer in the figure is very small, having the same rating as the high-frequency generator.

In three-phase systems, the transformers may be delta-connected, or there may be no ground. A high-frequency ground may be provided by connecting the neutral to ground by means of a condenser. In case of the delta-connected transformers, the method of introducing the current shown in Fig. 3 may be used in three-phase form.

There are a few special considerations in the use of 500-cycle synchronous machines and the steps taken to keep them in phase opposition. The power required from these machines is that necessary to operate the relays and supply the high-frequency line loss. Two kilowatts are ample for a large system. Machines of this frequency synchronize quite as well as those of lower frequency, provided too much reactance is not present between the two. The length of a section of line to be protected is often sufficiently short so that the reactance between generators will not cause synchronizing difficulty. In case it does, however, the high-frequency voltage may be stepped up by means of a transformer in order to decrease the effective reactance. Normally the high-frequency potential need not be more than 250 volts, though it may run much higher on long lines.

Fig. 1 shows the generators driven by synchronous motors connected to the main power feeder. If this connection is made, there are two closed systems inter-connecting the motor-generator sets at two frequencies. If there is a difference in the phase angles of the voltages of power frequency at the two motor-generator sets, there must be flexibility in the inter-connection. This flexibility should occur in the power-frequency side of the motor-generator sets and may be obtained by the use of a flexible coupling between the two machines of the set, or by placing reactance in series with the synchronous driving motors. Either of these

devices will aid in keeping the high-frequency voltage closely in phase. A synchronous driving motor has been selected because it permits the auxiliary generators to supply power at constant speed and frequency. The constant frequency is essential to prevent the parallel shunts and line impedance from departing from resonance.

The final component of the system needing special discussion is the relay. In Fig. 4 a 500-cycle mechanical relay is shown which has two elements connected in series. The function of the relay is to trip if a rapidly rising current of sufficient value is passed through it. This limitation of a rapidly rising current is obtained by the use of the second element. The dashpot shown in the figure will slow down the second element whose function is to tighten the spring restraining the tripping element such that if the current rises slowly a very high value will be necessary to trip the main element. The purpose of using such a relay is to prevent synchronizing currents between the generators, which currents must rise slowly on account of the mechanical inertia of the generators, from causing the relay to operate. A second purpose is to "pre-set" the tripping element as the load upon a section of protected line varies or as the

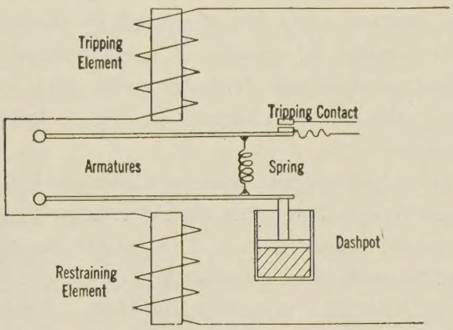

FIG. 4—HIGH-FREQUENCY PRE-SETTING RELAY-SCHEMATIC DIAGRAM

generating capacity connected to the section of line varies.

A vacuum tube relay may be substituted very nicely for the mechanical relay, with the advantage of increased speed. A relay used for this purpose is shown in Fig. 5. It is a neon-filled tube with a double purpose; first, to break down at a predetermined voltage in the manner of the well-known glow tube, and second, to pass a high circuit breaker tripping current as a mercury arc rectifier. The two lower electrodes consist of mercury pools, and the upper electrode is a hollow metal cone. If the voltage between the upper electrode and the smaller lower arc reaches a given value, a glow discharge occurs between the two, which causes a mercury arc to be formed between the upper and main lower electrodes. The tube is a further development by D. D. Knowles of the earlier Knowles' Grid-Glow Tube. It is capable of momentarily passing a tripping current of a few hundred amperes. The entire action is very rapid.

The connections using the tube relay are shown in Fig. 6. The device at the left takes the place of the pre-setting element on the mechanical relay. The entire relay apparatus in this case operation from voltage, actually the voltage of the current transformer in the line impedance circuit with a high impedance across its secondary. The pre-setting device consists of a one-to-one transformer whose exciting current is

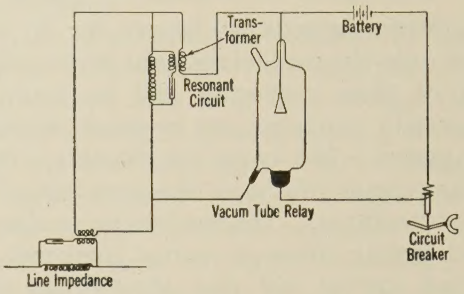

FIG. 5—HIGH-FREQUENCY VACUUM TUBE RELAY

obtained from a resonant circuit. The transformer connections are made in such a manner that the secondary voltage, under steady state, opposes the primary voltage and leaves zero voltage across the tube. During the transient, however, as a voltage is applied, the rise of the primary exciting current is very slow, and initially there is a voltage across the tube. Then the tube will operate if the voltage is rapidly increased to the breakdown point, but will not function with a slowly rising voltage.

Mention has been made of the feature of automatic

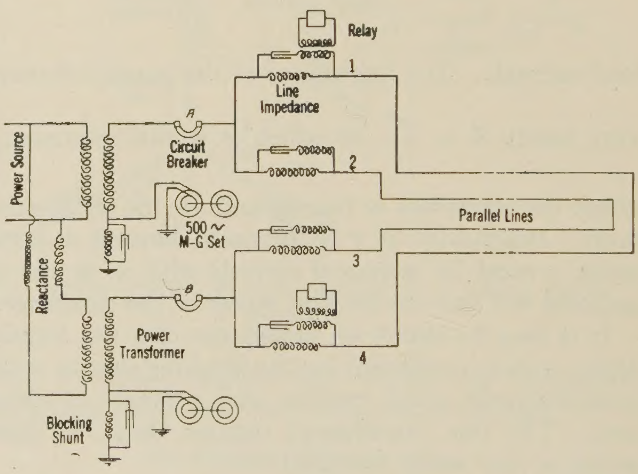

FIG. 6—CIRCUIT USING THE VACUUM TUBE RELAY

reclosing of circuit-breakers. If the circuit breakers in Fig. 1 are shunted with a condenser which will pass the high-frequency current only, with the circuit-breaker open, the high-frequency current will retain the relays in their operative position as long as the fault remains on the line. However, at any time that the fault is removed, the relays will return to normal and permit the breaker to reclose. Such a connection

would be advantageous if the protected system is liable to faults of short duration.

Results of Experimental Investigation

For the purpose of making an oscillographic study of the system, it was applied experimentally to an 11,000-volt test track contact line at the Westinghouse Works in East Pittsburgh. The experimental circuit is shown in Fig. 7. Four lines were used, and they were joined in pairs at one end in order to give two parallel lines with both terminals at the same location, the latter being for ease in testing. The lines were fed by 11,000-volt single-phase transformer banks at both ends. Two blocking shunts were placed in the grounded side of the transformers and a line-impedance was placed in each line. Arrangements were made so that a short circuit could be applied to either end of either line. Vacuum-tube relays were placed on lines 1 and 4, and were connected to trip the circuit breakers *A* and *B*. The

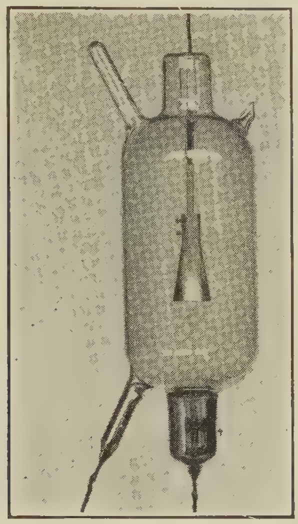

Fig. 7—Circuit of Experimental Test

apparatus was set up mainly to demonstrate speed of relay action and selectivity.

From the previous description it is obvious that a short circuit at the end of the line is the most severe condition to meet. Selectivity is most difficult to obtain, and there is the greatest danger of the auxiliary generators running out of synchronism with the short circuit at this point.

The first tests were made with high-frequency current alone applied to the line. The relays may be properly set, therefore, without the application of power current, by placing short circuits at the various indicated points and adjusting the tube voltage so that it trips with a fault on line (1-4) but not with a fault on line (2-3). The tube relay circuit was that shown in Fig. 6. In making these first tests the low-tension side of the power transformers must be short-circuited.

The frequency used was 525 cycles obtained from a small rotating machine, at 250 volts. Standard oil-filled condensers were used in the impedance circuits; the current transformers also were standard. The oscillogram in Fig. 8 was taken with a short circuit at the end of line 1. The lower element recorded the high-frequency current flowing from line to ground. The other two elements are a record of the current in the upper electrodes of the tube relays at 1 and 4. It will be recalled that both the circuit breaker tripping current (d-c.) and the high-frequency breakdown current flow in this electrode. The film, then, shows the high-frequency current superimposed upon the direct current. The d-c. component is similar to that which flows in the tripping coil of a circuit breaker, and the shape of the curve is familiar. The high-frequency component will be seen to gain in magnitude. The first tube operated two and one-half cycles, high frequency, after the short circuit occurred, and the second tube, two cycles later.

A potential of 11,000 volts was then applied to the lines at a frequency of 25 cycles. A short circuit was placed on line (1-4) at 4, and Fig. 9 is a record of the short-circuit current in line (1-4) at 1 and of the current in the tube relay at the same point. There is no discernible time lag from the instant at which the fault was applied to the instant at which the relay furnished tripping current to the breaker. The actual time, obtained from other tests, is about 1/2000 of a second. This time is independent of the point on the power frequency voltage wave at which the fault is applied, but will vary slightly, depending on the point of fault application on the high-frequency wave. The maximum time is about one-quarter cycle, high frequency. Fig. 10 shows the breakdown voltage of the two tubes, from which it will be seen that the voltage reaches its maximum in one-quarter cycle. The striking feature of the films is that it is not necessary for the relay to wait until the power current becomes excessive before operating. It will be noticed that the speed is much greater with power current on the line, because of the initial charge of the condensers. Fig. 11 shows the short circuit and tube currents with a fault on the line (2-3). Neither tube operated, indicating the perfect selectivity.

Conclusions

In principle, super-frequency control has four inherent characteristics which contribute to its value. First, high-frequency currents "know more about reactance" than those of low frequency, which means that the small differences in line reactance which describe the distinction between a fault or normal load may be more easily detected with high frequency. In the second place, by the use of certain high-frequency blocking devices placed in the lines, a network having any degree of complication may be broken up into a number of simple networks at the high-frequency, each of which may be independently measured. This possibility provides a high degree of selectivity between

various lines, and independent isolation of faulty conductors without the drawback of time delay.

The third characteristic is that, inherently, high-frequency currents reach their peaks on relay operating values more rapidly than those of normal frequency, thus insuring a high speed of relay operation. Finally, the high-frequency superimposed currents measure the

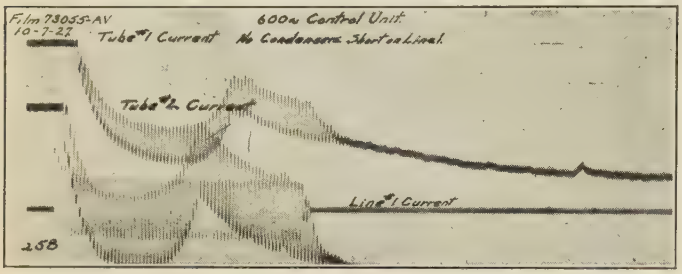

Fig. 8—Oscillogram of Relay Action with High Frequency Alone

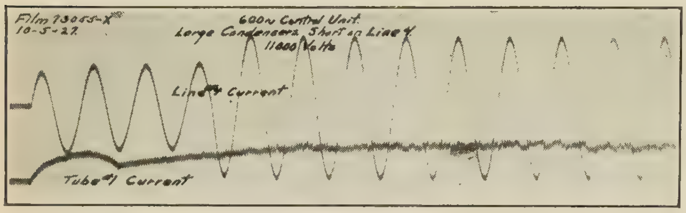

Fig. 9—Oscillogram of Relay Action Under Short Circuit Condition

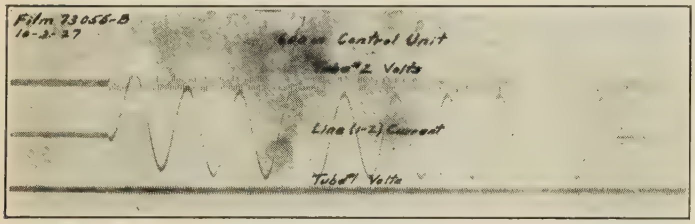

Fig. 10—Oscillogram of Voltage Across Relay During Short Circuit

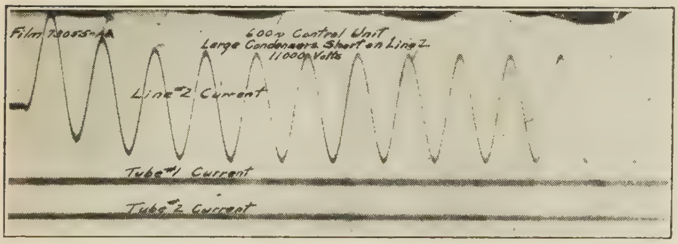

Fig. 11—Oscillogram Showing no Relay Action With Short Circuit on Parallel Line

pure impedance of a network, which is not possible with low frequency because of the counter-electromotive force of connected machinery. The advantage of the latter is an independence on the part of the superimposed system of all conditions of loading previous to a fault, an advantage which enhances recognition of fault conditions.

These inherent advantages lead to many possibilities. In general, the margin by which relays operate or do not operate may be considerably extended. Furthermore, the elimination of many variables in the power circuit by the use of high frequency makes possible accurate and simple calculation of relay operating currents. There are no particularly new principles involved and the system is simple enough to make possible its application to many of the more complex problems in circuit-breaker control.

A great many variations of this super-frequency control are possible, and have entered into experimental work and calculation. The system described has been used in an experimental way only, in order to demonstrate the soundness of its theoretical nature. The results obtained have been interesting and unique, and in themselves predict the future development of a super selective relay equipment.

MODERN LEGERDEMAIN

There is always something fascinating about the sleight-of-hand performer and his amazing series of impossible tricks. Even the small boy, however, realizes that twenty pink rabbits cannot be contained simultaneously in the one silk hat from which they are apparently drawn, and that the bowl of goldfish has not vanished into the air when the mystic passes have been completed over the soft blue cloth. Why are some power-station engineers so engenuously credulous about their ability to cause equally tangible materials to disappear without trace? * * * *

A steam generating station utilizing 500 tons of coal a day with a conservatively estimated ash content of 6 per cent has 30 tons of solid material to dispose of properly whether a stoker-fed boiler or pulverized-fuel equipment is used. Some of it will inevitably reach the open air; with stoker-fed furnaces this is relatively limited. It is amazing to hear engineers who have lived and worked through the era that has minimized the smoke nuisance state that they do not know where the ashes go and that there is an almost negligible quantity of which to dispose. The ashes, as any one on the leeside of the plant and possibly many miles away can tell you, are floating gently down on the countryside. * * * *

Official data of test runs in one pulverized-fuel installation where special precautions have been taken to control ash deposits indicate that while an average of 3.68 per cent of the dry coal is reclaimed as slag from the combustion chamber, the total flue refuse per pound of dry coal burned amounted to 0.0994 pound. Slowly indeed has industry learned that refuse is not disposed of when acids and dyes are poured into previously attractive streams, that smoke pollution of the air is a civic offense, in addition to being unprofitable, and that valleys were not made for refuse pits. The past points the way. Ashes must be disposed of, not blown into the air and forgotten by all but one's neighbors —*Electrical World.*

Electric Welding of Pipe Lines

BY J. D. WRIGHT[1]
Associate, A. I. E. E.

Synopsis.—This paper outlines the process of manufacture of steel pipe from flat rolled steel plates by automatic metallic arc welding. Data are given showing the physical and chemical analysis of the plate, the weld, and the welding wire, as well as the speed of welding and electrode and power consumption.

* * * * *

THE economies which have been effected in many manufacturing operations during the past few years by the adoption of electric arc welding for manufacturing as well as for tool repair have been so outstanding as to command the attention of all industries.

In many cases, the reduction in cost has been accompanied by a distinct improvement in quality, so that in these days of increasingly keen competition, no manufacturer marketing a product in which fabricated metal parts are, or might be used, should fail to make a thorough study of the possibilities of electric welding.

One of the newer applications of automatic arc welding is in the fabrication of pipe from flat rolled steel plates. It is particularly applicable to the larger sizes of steel pipe which heretofore have been made either by riveting, by the lock-bar process, or by the hammer weld process. The interest aroused by several successful installations of lines of pipe fabricated by the electric arc welding process has been very widespread, and it is the purpose of this paper to discuss the present state of the art as exemplified by a recent installation.

The example selected is the process employed for fabricating the pipe for a line approximately eight miles long, to convey water from the Provin Mountain Reservoir to the City of Springfield, Massachusetts. From the reservoir to the west bank of the Connecticut River, a single line of 54-in. and 48-in. diameter pipe is used. Two lines of 36-in. diameter each are laid under the Connecticut River, and from its east bank a single line of 48-in. and 42-in. pipe connects with the present distribution system of the City of Springfield. The thickness of the plate used in the pipe varies from 5/16 to 1/2 in.

Tests of Welded Joints

Before bids on welded pipe were submitted, tests were made to determine the strength of the welded joint and a definite procedure was worked out to insure thoroughly reliable and uniform results.

The plates used for the tests were of fire-box steel with tensile strength between the limits of 52,000 and 62,000 lb. per sq. in., as specified by the Engineer of the Board of Water Commissioners. The following shows typical analysis and physical properties of the plate steel:

Carbon	0.20 per cent	Yield point—	35,450 lb. per sq. in.
Manganese	0.40	Tensile strength	57,500 lb. per sq. in.
Phosphorus	0.015	Per cent elongation	31.5
Sulphur	0.029	Per cent reduction of area	56.3

Sections 3 in. wide by 48 in. long were sheared from ½-in. plate, and the sections beveled on one 48-in. side as shown by Fig. 1. Two sections were then welded together using the multiple arc process. This will be described in greater detail later. Two beads were deposited, the first with 3/16 in. G. E. type "F" welding electrode using 300/320 amperes at an arc voltage of 18/22, and the second with 3/16 in. G. E. type "B" electrode using 320/360 amperes and 18/22

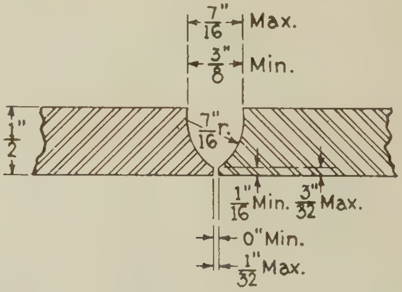

FIG. 1—DIMENSIONS OF BEVEL FOR WELDING ½-IN. PLATES

volts. The welding was done at a speed of approximately 4½ in. per minute.

The following table shows chemical analysis of the two welding electrodes:

	G. E. type "B"	G. E. type "F"
Carbon	0.10 max.	0.13/0.18
Manganese	0.25/0.45	0.40/0.60
Sulphur	0.045 max.	0.03 max.
Phosphorus	0.03 max.	0.45 max.
Silicon	Trace	Trace

Type "F" is a solid wire to which a special treatment is given to insure a uniform flowing quality. Type "B" has a center metallic core surrounded by a layer of flux, the whole being incased in a metallic sheath.

The welded plates were cut into strips 1½ in. wide and tested for tensile strength in a standard testing machine. The following results are typical of many specimens:

1. Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928.

Specimen	Tensile strength lb. per sq. in.	Failure
1	56,700	Weld
2	61,700	Weld
3	60,200	Steel
4	61,870	Steel
5	55,700	Weld
6	60,600	Steel

Other specimens were subjected to various bend tests to check the ductility of the weld.

Fig. 2 shows very clearly the metal deposited by the first and second arcs and the zone in the plate stock into which the heat of the weld has penetrated. Photomicrographic studies of the grain structure of the steel in the weld and adjoining plate show total lack of a definite line marking the transition from the weld to the plate, and no evidence whatever of any injury to the plate, owing to heat of the weld.

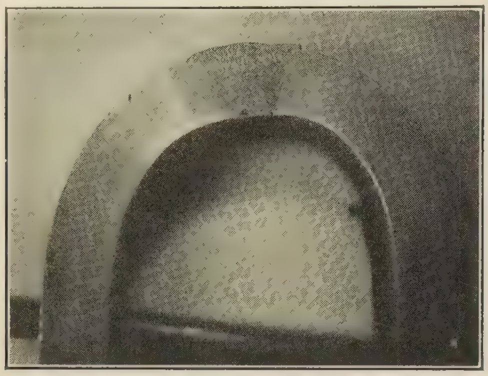

Fig. 2—Deeply Etched Section of Multiple Arc Welded ½-in. Plate

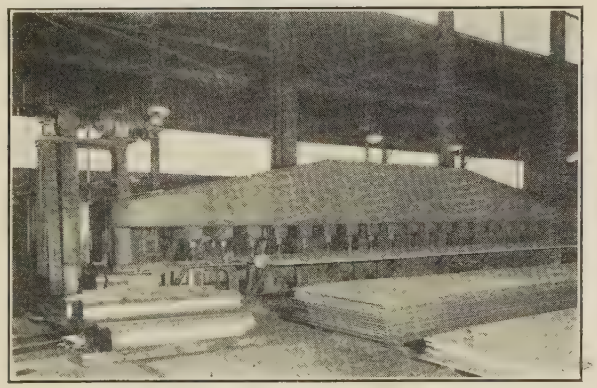

Fig. 3—36-ft. Plate Planer With Two Plates in Position for Machining Bevel on 30-Ft. Side

Manufacture of Pipe

The pipe for the Springfield water line is made in 30-ft. lengths from two 30-ft. plates which are bent into half circles and automatically arc welded together. Some consideration was given to welding of the circumferential joints in the field, but because of considerable opposition, it was decided not to do this on this particular job, and the 30-ft. sections are riveted together. To provide for this the plates are sheared so that the pipe diameter increases slightly from one end to the other, thereby permitting the small end of one section to fit into the large end of the next section an amount required for the riveted joint.

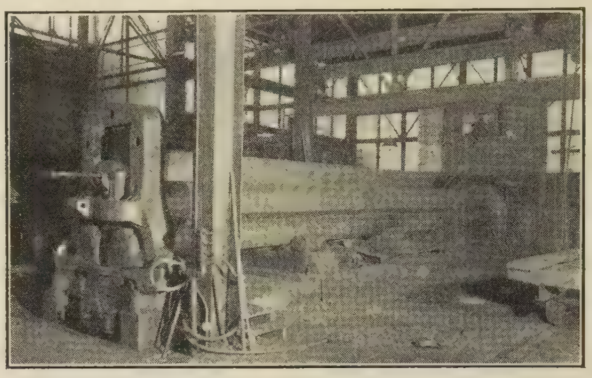

Fig. 4—36-Ft. Bending Rolls Forming 30-Ft. Half Section of 48-In. Pipe

The first operation in the manufacture of the pipe after the flat plates have been sheared to size is to bevel the sides accurately as shown in Fig. 1. This is done simultaneously on two plates on the plate planer shown in Fig. 3. On each plate, two lines are then scribed, each parallel to the upper edge of the bevel and ¾ in. from it.

The plate is then taken to the bending rolls, (Fig. 4), and by means of a special jig, the two 30-ft. edges are bent to the proper radius. The whole plate is then formed into a true half circle. Next the two halves of the pipe are placed in a specially designed frame, (Fig. 5), and tack welded together approximately every 16 in. on the inside by hand. After the raised portions of the beads are removed by grinding, the pipe is placed in the automatic welding machine, (Fig. 6).

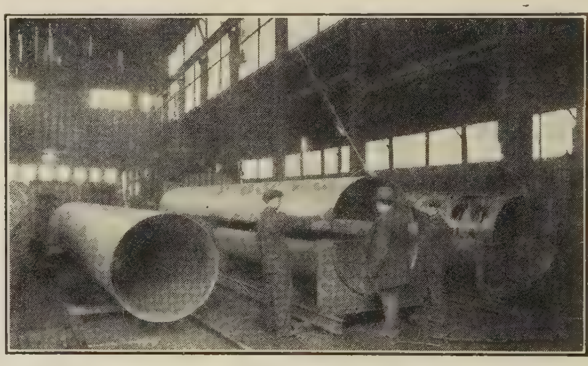

Fig. 5—Frames of Special Design Support the Two 30-Ft. Half Sections of 48-In. Pipe When Being Tack Welded by Hand From the Inside

Pipe Welding Machine

The pipe welding machine consists essentially of three horizontal beams, two above and one below.

Enclosed in the lower beam and extending throughout its full length are several sections of fire hose to which compressed air can be admitted. On the hose rests a series of plungers which in turn supports a "backing-bar," the latter being fitted with a flat copper chill bar approximately two inches wide. Application of compressed air causes the hose to expand, thereby raising the plungers, and the copper strip in the backing-bar is

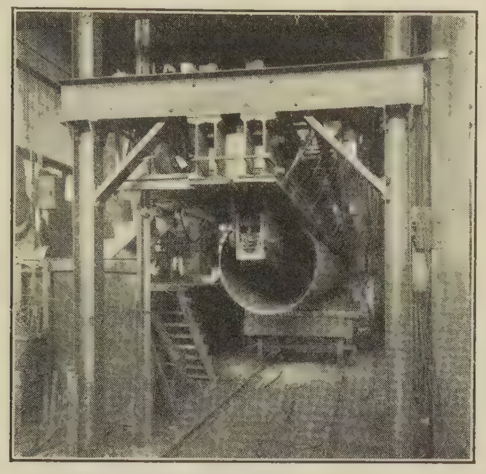

Fig. 6—End View of 36-Ft. Pipe Welding Machine Showing 30-Ft. Section of 48-In. Pipe Ready for Automatic Arc Welding of Longitudinal Seam

pushed up against the under side of the joint at a pressure of 200 lb. or more per running inch. The backing-bar is also provided with an insulated conductor which forms part of the return circuit for the welding current. By shunting the proper amount of current through this bar when the pipe is being welded, the

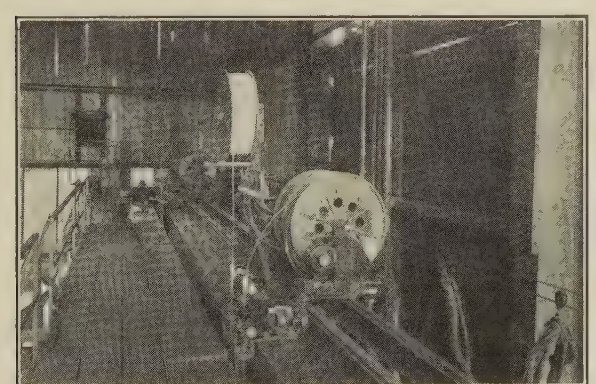

Fig. 7—36-Ft. Pipe Welding Machine Showing Two, Travel Carriages Each With Two Welding Heads for Automatic Welding of Pipe by Multiple Arc Process

magnetic disturbances of the arc can be very effectively controlled.

To the lower side of the upper beams of the machine are attached two copper jaws spaced approximately two inches apart and the pipe is placed in the machine so that the joint to be welded is located centrally between these two copper jaws and directly over the copper strip in the backing-bar.

The multiple arc welding process previously mentioned employs two arcs, one following about eight inches behind the other. The two automatic welding heads, used to feed the wire, are mounted on a single motor driven adjustable speed travel carriage, (Fig. 7), which moves the heads along the work at the proper welding speed.

When work was first started on the manufacture of the pipe for the Springfield line, only one travel carriage with two welding heads was used. This carriage, of course, traveled the full length of each 30-ft. seam. A little later, a second travel carriage with two more heads was added. Welding was then carried on simultaneously with four arcs, one carriage starting at one end and the other at about the middle of the seam. This reduced the welding time per pipe by about 50 per cent. It is expected that a third carriage with two more heads will soon be added, each pair then welding about one-

Fig. 8—48-In. Pipe, 30 Ft. Long Fabricated From Two ½-In. Plates by Automatic Arc Welding Undergoing Hydrostatic Pressure Test of 240 Lb.

third the total pipe length with corresponding reduction in welding time.

After one seam is completely welded, the pneumatic clamp is released and the pipe is rotated to bring the second joint into position for welding.

Speed of Welding; Electrode and Power Consumption

The speed of welding attained by the multiple arc process with two welding heads on ½-in. plate is about 22½ ft. per hour. Using approximately 380 amperes on the first arc and 330 amperes on the second, the total consumption of 3/16-in. electrode is from 0.8 to 0.85 lb. per foot of weld. These welding currents are somewhat different from those used when the test plates were welded, but were found to give better results on the joint between the two sections of pipe. Current for each pair of welding heads is obtained from a 1000-ampere 1-hr. rated constant potential welding generator driven by an induction motor. The power consumed is approximately 2.15 kw-hr. per foot of weld on ½-in. thick plate.

Inspection and Tests of Welds

At the request of the inspector, test plates having a bevel as specified for the pipe joints are placed in the machine and welded under the same conditions as the pipe itself. These plates are then cut into specimens and tested.

The extent to which the weld is reinforced, that is, its height above the surface of the plate, is usually from 1/16 to 1/8 in. The minimum and maximum values permitted by good practise are 1/32 and 3/16 in. respectively. The weld bead must not be less than 5/8 in. nor more than 1 in. in width and must also be central within 1/16 in. between the lines scribed on the plate each side of the joint. Any holes which are seen on the top surface of the deposited metal are carefully chipped and if they extend below the surface of the plate, the spot is rewelded by hand. The edges of the bead are also examined to see that the weld metal is thoroughly fused along the top of the plate. Any cracks or hollow spots are chipped and rewelded by hand.

Fig. 9—30 Ft. Section of 48-In. Pipe About to be Lowered into Electrically Heated Vertical Dipping Tank to Receive Protective Coating of Coal Tar Pitch Varnish

Fig. 10—Laying of Steel Pipe Line for Springfield, Mass., Water Supply. 30-Ft. Longitudinal Joints are Automatically Arc Welded. Circumferential Joints Made in the Field are Riveted

To determine the amount of penetration, the under side of the welded joint is carefully examined. It is necessary that the metal be so thoroughly fused that no crack can be seen between the edges of the plate.

After the welded pipe has been given a careful visual inspection and any defects rewelded, it is placed in the testing machine, (Fig. 8), and subjected to the following hydrostatic pressures in pounds per square inch:

Thickness of pipe in inches	5/16	3/8	7/16	1/2
66-in. pipe	..	160	..	..
54-in. pipe	135	160	187	213
48-in. pipe	..	..	210	240
36-in. pipe	..	..	..	320

Dipping and Laying the Pipe

The rivet holes are then punched in each end of the pipe after which it is thoroughly cleaned and dipped vertically in an electrically heated tank of coal tar pitch varnish, (Fig. 9). The pipe is submerged in the bath long enough to heat the metal uniformly to the temperature of the bath. It is then removed and suspended in a vertical position until the coating has drained and set.

The pipe is then ready for transporting to the field and laying in the trench, (Fig. 10). After the pipes have been properly placed and connected by temporarily bolting, the circumferential joints are riveted and caulked. The middle portion of each length of pipe is then backfilled but the field joints are left exposed until the line has been tested for tightness.

Conclusion

At the time this paper was written, approximately three miles of pipe had been delivered to the field, and its installation in the trench was progressing rapidly.

The advantages gained by the electric welding of pipe as compared with other methods of manufacture are; a very substantial reduction in cost and a superior finished product. The reduction in cost is secured not alone by the decreased weight of steel required but also by a reduction in the cost of the actual work of fabricating the pipe.

Owing to the smooth interior of the welded pipe as compared with the riveted pipe, the resistance to flow is decreased. The circumferential joints are made more easily with welded pipe because of uniform wall thickness whereas with riveted pipe the wall is of double thickness at the riveted joint. The joining of the ends of pipe made by the lock bar process is rendered difficult owing to the presence of the bar.

Arc welded pipe is also invading the field of lap welded pipe produced by the lap weld mills because of the fact that the thickness of the wall of the latter is fixed and often times the pressures are such that much lighter arc welded pipe can be used with consequent reduction in the cost of the line.

Abridgment of

Recent Inprovements in Turbine Generators

BY S. L. HENDERSON* and C. RICHARD SODERBERG*

Synopsis.—*During the last few years there has been a very rapid increase in the rating of turbine generators. A considerable amount of development work has been necessary in order to make these increases possible, and this paper gives a summary of the problems which have been encountered, and solved, by engineers of the Westinghouse Elec. & Mfg. Co. The present status of the design of turbine generators is given, and the probable directions of future developments are indicated.*

I. Introduction

THE object of the present paper is to describe some of the problems that have been encountered in the development of the turbine generator in the last five years. The increase in the size of the individual units during this period has been very remarkable, particularly in the last two years.

In the two-pole, 1500-rev. per min. class, the maximum output of a single generator in 1925 was 66,700 kv-a.; at the present time, there is under construction, a single unit of 160,000-kv-a. capacity. In the four-pole, 1800-rev. per min. class, the maximum rating in 1924 was 44,400 kv-a.; at the present time, a unit of 94,000-kv-a. is being built.

II. Ventilation Problem

The capacity increases which have taken place within the last five years have been obtained chiefly by increasing core length. Even in the largest units built five years ago it became increasingly difficult to supply all the cooling air from both ends of the machine, not only because of the excessive air pressures required, but because of the increase in temperature of the cooling air as it passed through the machine. This latter factor was particularly important in long, axially ventilated machines.

Multiple radial ventilation solved this difficulty and it is now possible to obtain fully as uniform a temperature distribution for core lengths of 250 in. as for 100 in. The multiple radial ventilation was extensively investigated several years ago by Fechheimer,† Bratt, and others of the Westinghouse Company, and while the system was not new at that time, an exact predetermination of the dimensions of the air circuit had not been undertaken previously.

For more than five years, the project of ventilating generators with hydrogen has been under active consideration by designing engineers. The most important advantage connected with the use of hydrogen is the reduction in windage loss. In an 1800-rev. per min. generator, the windage loss is the largest single item and amounts to slightly more than one per cent of the kw. rating. This loss will be practically eliminated through the use of hydrogen.

While no machines have actually been installed, using hydrogen as a cooling medium, several turbine generators have been sold with the provision that hydrogen may be used later, and a large synchronous condenser has been sold for immediate installation with hydrogen cooling. Experimental work is being actively prosecuted and the Westinghouse Company has an experimental 7500-kv-a. generator operating with hydrogen cooling.

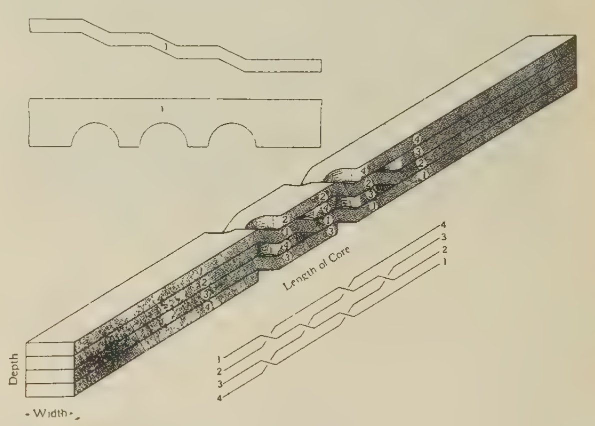

Fig. 1—Internal Strand Transposition

III. Design of Stator Coils

In order to build machines of extreme core length, it became necessary to modify the coil design. Previously it had been customary to build the coils in one piece, two coil sides being wound continuously. The great lengths required by these large ratings make the coils too heavy to be handled in one piece so that it is necessary to divide the coil in two at the rear. Such a construction facilitates the insulation of the coils and the winding of the coils in the machine. As it is impossible to connect the strands individually at the rear because of lack of space, it is necessary to connect groups of strands together. This requires that the

*Both of Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

†C. J. Fechheimer, *An Experimental Study of Ventilation of Turbo Alternators*, A. I. E. E. Trans., Vol. 43, 1924, p. 476.

D. Bratt, *The Multiple Radial System of Cooling Large Turbine Generators*, A. I. E. E. Trans., Vol. 43, 1924, p. 467.

C. J. Fechheimer and G. W. Penney, *Concluding Study of Ventilation of Turbo Alternators*, A. I. E. E. Trans., Vol. 45, 1926, p. 253.

C. J. Fechheimer, "Performance of Centrifugal Fans for Electrical Machinery," *A. S. M. E.*, 1924.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., February 13-17, 1928. Complete copies upon request.

strands in the group must be transposed in the slot in order to reduce the eddy current-loss. Such a transposition is illustrated in Fig. 1 (4).

The question of armature coil insulation has been given considerable study in preparation for these large units. Improvements in the mica folium have been made to correct swelling and wrinkling of the insulation. The swelling of the insulation has been found to be due to the vapor pressure caused by the alcohol in the shellac bond in the mica and, to some extent, to the moisture in the paper for backing the mica. As a result of this investigation, a new bond was developed which has practically eliminated swelling.

IV. General Design

Efficiencies have been improved through the use of silicon steel in the stator laminations. Turbine generators are now built with a grade of steel equal to the best

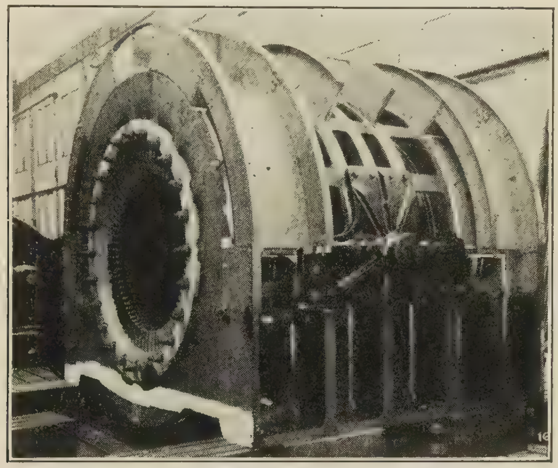

Fig. 2—Skeleton Frame Construction

steel used in transformers. The old fear of brittleness of silicon steel has been corrected by improved methods in stacking the punchings and by larger fillets at the bottom of the slots. The use of silicon steel reduces the iron loss to 45 per cent of the value obtained with non-silicon steel.

The question of short-circuit ratio and voltage regulation have not been of serious moment in the past largely because turbine generators are usually installed near the center of load, and the problems connected with long distance transmission have not yet arisen. In some cases these factors may be of importance, but no general values can be laid down, as each case furnishes a special problem. It is desirable for specifications not to call for too high a short-circuit ratio, as the cost per kilowatt may increase or the maximum possible size of generator be limited.

V. Stator Construction

The weight of the stator has been decreased by a change in the frame construction. In the earlier productions, the section of the frame was determined chiefly by the demands of the ventilating system, because the casting included the ducts for conducting the cooling air to and from the core. The frame is now made with sufficient strength to support the punchings, and the ducts for the air, built on the outside of the frame with structural materials. A frame with a portion of this housing in place is shown in Fig. 2 (9). This super-structure is removed during shipment and so decreases the weight of the heaviest piece to be shipped. It is now possible to build generators of approximately 100,000-kv-a. capacity complete at the factory.

VI. Mechanical Construction of the Rotor Body

a. Working Stresses. The problem of determining safe and economical working stresses for the various parts of the rotor body, is a most important and difficult one, particularly for those points where the bending stresses act in conjunction with the centrifugal stresses. At those points the application of stress is two-, and sometimes three-dimensional, and the variable components of the stress must be considered with proper allowance for stress concentration.

One of the most important advances during the last years is a better appreciation on the part of the designers of the fact that the stress problem has two aspects. One is the comparatively simple one of determining the stresses that actually exist in the structure. The other is the far more difficult one of determining the actual condition of failure under these stresses. The solution of the latter problem finds its expression in the determination of true factors of safety, and in the actual values of the allowable working stresses. In view of the importance of this problem it may be of interest to review briefly the present attitude of Westinghouse engineers.

In cases of *steady stress* in ductile materials, the *yield point* is regarded as the fundamental basis for the selection of the working stress. The failure of the material is attributed to shear, so that in cases of three dimensional applications of stress, the *maximum shear theory*, giving the maximum difference of the principal stresses as the critical stress, is made a basis for determining conditions of failure. Conditions of stress concentration are generally disregarded for steady stresses in ductile materials. The factor of safety is thus the ratio of the yield point to the average critical stress.

Cases of *variable stresses* in ductile materials offer somewhat greater difficulty, but even here it has been possible to obtain a logical definition of the true factor of safety. One of the most important features of applications of variable stresses is that the conditions of stress concentration must be taken into account, so that the stresses obtained by ordinary elementary formulas must be multiplied by a factor of stress concentration k. This, however, applies to the variable component of the stress only. In the case of complete reversals of stress in one direction the *endurance limit*

for complete reversals is regarded as the fundamental basis for the selection of the working stress. The factor of safety is thus the ratio of endurance limit to maximum alternating stress.

In the more general case of a variable stress, which is superimposed upon a steady stress, it has been found that the available experimental data are interpreted in a logical manner if the actual factor of safety n is determined by the formula

$$\frac{1}{n} = \frac{1}{n_o} + \frac{1}{n_v} \quad *$$

where n_o and n_v are the factors of safety of the static

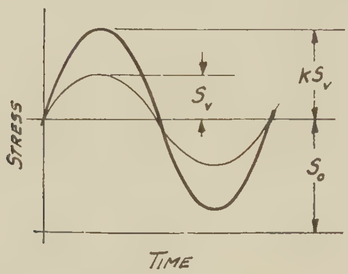

FIG. 3—GENERAL STRESS CYCLE

S_o = Static component of stress
$k\ S_v$ = Variable component of stress
K = Factor of stress concentration

and variable components of stress, respectively, when acting alone.

$$K\,S_v = \frac{\frac{S_e}{n}}{\frac{S_y}{n}}\left[\frac{S_y}{n} - S_o\right]$$

whence $$\frac{1}{n} = \frac{S_o}{S_y} + \frac{K\,S_v}{S_e} = \frac{1}{n_o} + \frac{1}{n_v}$$

Cases of two- or three-dimensional applications of stress are treated by the maximum shear theory. It is necessary only to determine the most dangerous plane and the steady and variable component of shearing stress in this plane. The result is a cycle of shearing stresses similar to Fig. 3. Upon this cycle the postulated definition of factor of safety can be applied.

b. The Westinghouse Plate Rotor. The limitations of one-piece forgings were anticipated at an early date by the Westinghouse Company, and their present construction was originated by Behrend and Field over eighteen years ago.† It will be referred to in the following as the *plate rotor.*

Fig. 5 shows the general arrangement of this

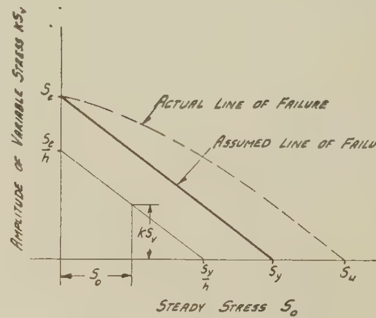

FIG. 4—CONDITIONS OF FAILURE UNDER GENERAL STRESS CYCLE IN ONE DIMENSION

construction. The rotor consists of two end forgings, A, and a series of plates, B, spigoted into the end forgings and into each other. The entire structure is held together by through bolts.

The mechanics of this plate rotor have been studied very carefully and its behavior is fully known. This study has shown that the rigidity of the construction is not impaired by the cutting of the holes for the rotor bolts, and the variation in the bolt stress is very small.

The plate rotor does not possess any limitations to increases in rotor length other than those caused by critical speed and shaft deflection. In these respects it is on par with the solid rotor. Its inherent advantages are due to the possibility of using high grades of steel

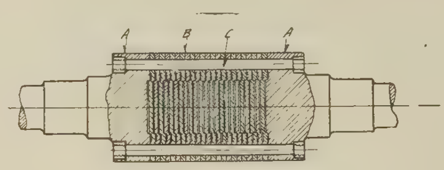

FIG.—5 LONGITUDINAL SECTION OF PLATE ROTOR

independently of the size of the rotor body, and the better facilities for rotor ventilation.

c. Development of Rotor Materials Large One-Piece Forgings. The attitude of the manufacturer with regard to the relative merits of one-piece forgings and the sectional construction has undergone important changes in the last two or three years. It is only a short time ago that most turbo designers were convinced that a satisfactory one piece forging could be obtained for any of the rotor dimensions within sight, if the price

*The justification for this definition of the true factor of safety can be demonstrated as follows.

Let Fig. 3 represent the stress cycle under consideration. The dotted line $S_e - S_u$ in Fig. 4 gives the experimental curve (See for ex. Timoshenko and Lessells, "Applied Elasticity," Page 477) denoting failure under this type of stress cycle. This is a parabolic curve starting at the endurance limit S_e and ending at the ultimate strength S_u. In view of the insufficient nature of the experiments, and in view of the fact that all stresses are limited by the yield point, this curve has been replaced by the straight line $S_e - S_y$, connecting the endurance limit and the yield point S_y. This is a defined line of failure giving a somewhat greater margin of safety than indicated by tests. Stresses giving an actual factor of safety of n are defined by the straight line $S_{e/n} - S_{y/n}$ which is parallel to the line $S_e - S_y$. The end points of this line are fully determined; the intermediate portion is arrived at by definition. It is evident that

†"Some Difficulties of Design of Turbine Generators," A. B. Field, *Journal I. E. E.*, Vol. 54, 1915, p. 65. B. A. Behrend, TRANS. A. I. E. E., Vol. 36, 1917, (Discussion) p. 883.

were forthcoming. The latest advances in the size of individual units has changed this condition; the present maximum size of rotors can no longer be built of one-piece forgings regardless of price and specifications.

The experience of the Westinghouse Company in obtaining large forgings for turbo rotors indicates that extreme care in the manufacturing of these forgings must be employed, and even then the electrical manufacturer is not completely guarded against rejections. The present status of the art of inspecting these forgings is such that flaws can be detected with certainty, but the expenses and delays of rejections are considerable.

As a result of this experience, the Westinghouse Company demands satisfactory test properties in the radial, tangential and longitudinal directions. This has raised the price of these forgings to a point where they have ceased to be competition with the plate rotor.

Materials of Plate Rotors. Up to a short time ago, the rotor plates were made from a 0.30 per cent carbon steel rolled in flat slabs to a thickness of 2¾ in., and machined to 2 in. By this method it was possible to obtain comparatively uniform material having a yield point of about 35,000 lb. per in.^{2} and an elongation of about 25 per cent.

During the last two years there has been developed a new type of material by which it is possible to obtain plates of a thickness of about 7½ in., having a *yield point of 65,000 lb. per in,*^{2} and an elongation of over 25 per cent. Properties of this nature in a comparatively inexpensive carbon steel are truly remarkable, and the importance of this metallurgical development as an aid to the construction of these large rotors can not be over-estimated.*

The Problem of Assembly of the Plate Rotor. After machining the plates and shaft ends, they are assembled with temporary bolts. The bolt holes are then reamed and the regular bolts inserted and tightened.

In order to place this tightening process on a more scientific basis a special pulling machine has been developed, whereby it is possible to stretch the bolts to their correct stress before the nuts are advanced. The introduction of this equipment has proved very valuable; from the point of view of uniformity of the results as well as production.

VII. Details of the Rotor Construction

The improvements in the details of the rotor construction have concerned the arrangement of the end windings and the rotor ventilation.

The insulation over the coil ends has a very heavy duty to perform, being subjected to high pressure and temperature and shearing action. Moulded asbestos channels have been developed for the tops of the coils, and the retaining rings are lined with the same material.

In the latest large rotors the retaining rings have to be shrunk on with a sufficient allowance to remain tight at the overspeed.

*W. J. Merten, American Society for Steel Treating, Ninth Annual Convention, Sept. 1927.

The recent improvements in the mechanical construction of the rotor fans have made it possible to equip 1800-rev. per min. machines of an output of 75,000 kv-a. with internal fans.

VIII. Critical Speeds

The problem of critical speeds in the rotor has played a peculiar role in the development of large machines, and its influence in placing limitations upon the rotor dimensions represents a striking example of the fact that complete absence of theoretical analysis may sometimes be preferred to unreserved faith in a faulty or partial analysis.

The fact that a rotor can be brought through its fundamental critical speed without danger has been well established for several years, but in spite of this there is still a general feeling on the part of some designers, and many customers, that it is very desirable to have the calculated value of the critical speed above the operating speed.

This attitude has actually been the cause of numerous

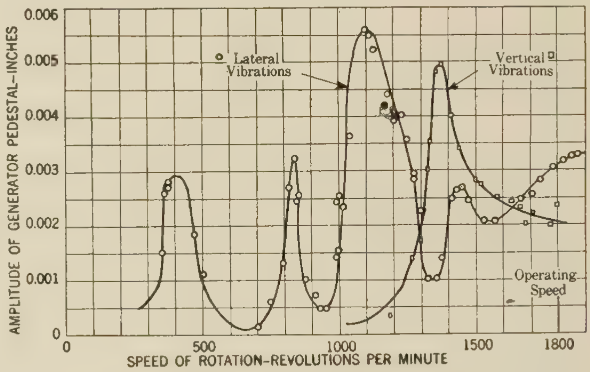

Fig. 6—Resonance Curves for Generator Pedestal of Four Bearing Turbine Generator Experimental Result Obtained from Arrangement shown in Fig. 34.

cases of vibration troubles, not to mention the important fact that it has constituted a damper on the logical expansion of the individual size of the units. The reason for these troubles has been found to reside in the fact that the actual critical speed of the rotor is determined, not only by its own flexibility, but also, and often to a greater extent, upon the flexibility of its supports. This influence is so great for large units with rigid rotor structures, that the recorded values of the critical speeds are frequently only half of the calculated values. As a result of this, many machines have been forced to operate very near to the actual critical speed.

The flexibility of the bearing supports is only one of the factors which cause the great discrepancy between calculated and recorded values. A fully satisfactory perspective of the problem is obtained only when the entire unit, with its foundation, is treated as one problem. It is here that the real limitations of mathematical analysis comes to light, and the practical designer is made to feel the true importance of intuitive judgment and good luck.

Fig. 6 shows an example of speed-amplitude curves which were obtained from the outboard pedestal of a 30,000-kv-a. turbine generator on a typical steel foundation. The maximum peak occurred at 1200 rev. per min. This was found to represent the fundamental critical speed of the rotor, calculated at 2380 rev. per min.

The term "critical speed," then, has assumed a significance entirely different from that of a calculated value for the rotor alone. The chief object of the analysis is to enable the machine to run in a hollow of this resonance curve, and no method, short of scientific foundation analysis, can lead to this result.*

IX. Balancing and Vibration Problems in the Shop and in the Field

One of the most important aspects of the development of the last five years concerns the improved facilities for balancing in the shop as well as in the field.

The balancing machine has been developed to a high degree of perfection and the only difficulty of this part of the shop process is the fact that a rotor reaches stability only after prolonged seasoning.

The facilities for solving balancing problems in the field are now such that the inconvenience and expense that has attended vibration troubles have been reduced very materially:

*C. R. Soderberg, *Phil. Mag.*, January 1928. p. 47. "On the Practical Application of the Theory of Vibrations to Systems with Several Degrees of Freedom."

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Abridgment of

Progress and Problems From Interconnection in Southeastern States

BY W. E. MITCHELL[1]

Fellow, A. I. E. E.

Synopsis.—*Great progress has been made. Interconnection between independent systems is primarily a protective measure, but the greatest economic benefits have been realized when the interconnections have been made by subsidiary companies of one holding company. The capacity of tie lines and the amount of power interchanges has developed greatly. The size of generating units has increased, as has the size of power plants, resulting in lowered cost per kw. The problem of satisfactory voltage and power factor control has increased in complexity as has that of system load dispatching. While much improvement has been made in oil circuit breakers, they still leave much to be desired. Interconnection has made possible more economical operation of existing plants and has resulted in the use of a larger proportion of the available water on systems combining steam, storage, and run-of-river hydroelectric plants.*

Long-time forecasting of load and rainfall conditions is important in economical system planning. The 110-kv. and 154-kv. line construction is discussed; also the value of ground wires and lightning arresters. The growing importance of carrier current for supervisory control and communication and their application are reviewed.

* * * * *

In 1924 in a paper on Interconnection of Power Systems in the Southeastern States, the author suggested that our great problem for the next 10 years would be to increase the capacity of the interconnecting links between different systems; also to develop water power distant from the power market, and to construct the mine mouth or other strategically located (from an economic standpoint) high-capacity steam plants, connecting them with the great load centers by means of high-capacity networks. It was suggested also that we should plan for at least 10 years in the future.

Less than four years have passed, yet tremendous strides have been taken along these very lines. The economic possibilities of interconnection are being clearly realized. One of the results has been the coordination in a number of instances of the various individual operating companies under one holding company, thus deriving the benefit of massed capital, massed resources, and unified control. Interconnection, group management, low-cost steam generation, and long distance transmission have come as a logical succession of natural economic steps.

1. Alabama Power Co., Birmingham, Ala.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Feb. 13-18, 1928. Complete copies upon request.

Interconnection between independent systems is, first, a measure of protection in emergencies. It cannot be a success unless the executives and operating forces of the respective companies realize it is a give-and-take proposition, and have mutual regard for the interests of both companies in the service of the public.

In the Southeast, what we term an "operating committee," (on which there are representatives from Alabama Power Co., Tennessee Electric Power Co., Georgia Power Co., Columbus Electric & Power Co., Augusta-Aiken Railway & Electric Co., Southern Power Co., and Carolina Power & Light Co.), has been functioning for over four years. This committee meets about eight times a year and compares operating data, load, rainfall, storage reservoir conditions, and other problems of mutual interest. This has proved of the greatest value to all concerned. Getting better acquainted, with resultant better understanding and a greater knowledge of each other's systems—their points of strength or weakness,—has facilitated the prompt handling of the exchange of power in emergencies. Frequently, improved operating economies through interchange have resulted from a greater knowledge of conditions throughout the entire territory.

Unquestionably the greatest benefits, however, (and this applies both to the general public as well as to the individual companies) are derived when the interconnected companies, while maintaining their independent corporate identity, are subsidiaries of one holding company. It is practically impossible to have a unified development program for five independent companies, but if these are under the same financial, engineering and mangement control, genuine system planning on a large scale will take place, and the most economical plants and tie lines will be built first, looking only to the maximum results for the group as a whole.

The system of the Southeastern Power and Light Company is operated in parallel practically all of the time, and much of the time it is in parallel with both the Tennessee and Carolina systems. For successful parallel operation and, at the same time, to secure the proper load division between the various generating stations and between the systems themselves, it is essential that the frequency be very closely controlled.

We endeavor to maintain the frequency rigidly at 60 cycles. By the installation of master clocks at the larger generating stations, and the use of extremely accurate frequency recorders at load dispatching centers, it has been possible to make material improvement in the control of frequency over the interconnected systems.

During the wet season, the basic load is carried by the run of river hydroelectric plants, and the load fluctuations, by steam plants and vice versa during dry seasons. The system supplying the bulk of the power regulates the frequency. Special attention has been given to the adjustment of governors at all generating stations, so that they will be as equally sensitive as possible in order that all stations may carry their proper share of the load fluctuations.

As larger systems are tied together and additional interconnections are made, the problem of voltage control becomes more important and complicated. On the system of the Southeastern Power and Light Company, there is installed, at present, a total synchronous condenser capacity of 130,000 kv-a. In addition to this, the hydroelectric units when not needed to supply power are used for such power-factor correction as is required during the peak load hours. Usually, during the dry season of the year when steam plants are operating on base load, a large portion of the hydroelectric capacity is used during peak-load hours for power-factor correction. It is the practise, when these units are operating as synchronous condensers, to close the gates tightly. Vacuum breakers have been installed upon all of the more important units so as to reduce the power input to the generators when they are operated as synchronous condensers. In the more modern plants, automatic vacuum breakers have been installed. Naturally the hydroelectric plants are not so beneficial as synchronous condenser stations located at load centers. However, they are in general at opposite ends of the system from the steam plants, and therefore they have been of much use in the correction of voltage. It has been more economical to use them for this purpose than to install the additional synchronous condenser capacity which would be required.

To govern the division of load and wattless current, it has not yet been found necessary to install regulating transformers in tie lines, but it is very likely that this or some other method will be required as the number of ties between the systems increases. With the increasing amount of load carried over the lines, the problem of system stability has been encountered, and an extensive series of stability tests have been made in cooperation with one of the larger manufacturers. A technical paper is now being prepared describing these tests in detail.

On a large network system, it is becoming increasingly difficult, and, in fact, practically impossible, to make the necessary calculations for load division over transmission lines, voltage regulation, etc. Therefore, the practise has been established of at least once or twice each year taking simultaneous readings at all of the most important generating stations and load centers of the interconnected network. Readings of load, power factor, voltage, etc., are taken simultaneously and tabulated and are of considerable assistance in engineering calculations, as well as in the proper operation of the system.

The problem of relaying is becoming increasingly difficult as single-circuit transmission lines are added. A great need is being felt for a system of relaying which, while selective, will instantly disconnect a faulty circuit. At present, the ordinary induction type overload relays are being used on single-circuit lines, naturally having

a short time setting to secure selective operation. In a few instances it has been found that the settings on these relays have been such as to hold the short circuit on the system long enough to affect the system stability, and in one or two instances, has resulted in rather serious interruptions. Upon the double-circuit tower lines, the balanced relays are functioning very satisfactorily. However, frequently during lightning storms, both circuits on the tower lines are interrupted simultaneously.

As the systems grow larger, interconnection between those under one management makes for greater operating efficiency. Full advantage is taken of diversity of time, diversity in rainfall, and in seasonal load. Without the tie lines, this would be impossible. To a somewhat lesser degree, advantage may be taken of these same factors by means of ties between independent companies. With the large storage reservoirs, practically no water goes to waste during the summer season. If one section has a heavy rain and another none, the tie lines permit sale of the surplus at such a price that the company that has had no rain can afford to buy power and store its own water.

With the more careful studies of the curves of rainfall and run off and expected load, a greater use is made of all hydroelectric plants. The run of river plants which on the isolated system wasted water all night long because it had little or no storage, now that it is linked into a comprehensive system, generates many more kw-hr. than it previously did, thus probably saving fuel generation.

On a system combining run-of-river and storage hydroelectric plants and steam plants, great savings can be made by accurate knowledge of river flows and available plant capacities. This involves not only studies of all available data as to river flow in the past, but the forecasting of the future flows and the formulating of careful rule curves for the day-to-day operation of storage plants.

At the present time the first 66,667-kv-a. unit of four which will ultimately be installed in a new mine mouth steam plant at Gorgas is now under construction. This plant, together with the existing steam plants and the big storage plants at Martin and on the Tallulah River, make possible the maximum use by both Georgia Power Company and Alabama Power Company of their run of river hydro plants. All combine to develop more kw. of capacity per dollar of investment and to produce more kw-hr. at a lower cost than would be possible under independent management. In a similar manner, the Southern Power Company, the Carolina Power and Light Co., and the Tennessee Electric Power Co. are working to the same end on their great systems.

The time of the development of all the economical hydroelectric sites is not distant. The material improvement in steam generating efficiencies, together with the lowering plant costs, the reliability of the large steam units, and the varying character of our southern streams are all making utility engineers in the South realize that a greater and greater proportion of power will be produced by steam in the future.

The extent and feasibility of interconnection and long distance transmission was thoroughly demonstrated in 1925, when over 600 mi. of line between Muscle Shoals in northwest Alabama and points north of Raleigh, N. C., were linked up for several weeks and large blocks of power transmitted.

On December 3, 1927 systems from Chicago to Mobile and Pensacola were interconnected, and thus over 1000 mi. of transmission line and literally millions of kw. of generating capacity operated in parallel for some 15 minutes. No power was interchanged but the availability of the interconnections in case of emergency demonstrated.

The year 1927, so far as Alabama and Georgia were concerned, was nearly as dry as 1925. Georgia had very little additional generating capacity and a very greatly increased load. Due, however, to coordination of the systems and the additional tie lines, water was conserved in the Burton storage all during the spring and drawn out in the late fall when most needed. Under independent operation, the tendency would have been to have taken a chance on getting summer rain (which never came) and so to have drawn upon the stored water that when the final pinch came, there would have been none left. Then industries would have been forced to curtail because the tie lines could carry no more and the hydro plants would have been greatly reduced in capacity by lack of water.

In 1927 the Savannah River dropped to a flow nearly as low as in 1925. The local plant near Augusta was entirely inadequate under these conditions to carry the system load so that for several months from 15,000- to 20,000-kw. capacity was taken over the interconnecting 110-kv. line with the Georgia Power Company and thus a curtailment of industry in a large territory entirely avoided.

Another example of the greater use of available resources; Company A had available 25,000 kw. of transmission capacity but no surplus generating capacity. It was interconnected on one side of its system with Company B, which had surplus power, and on the other side with Company C, which was short of power. Transmission facilities were leased from Company A, power purchased from Company B, and Company C's needs were completely taken care of.

The growth of each independent system, (but even more the unified control of several systems), has promoted the use of larger power plants and larger generating units. When a system load is of the order of 400,000-kw., the annual growth will be at least 50,000 kw.; therefore, it is logical to install very large units. In the Buck steam plant, (a powdered fuel plant), which the Southern Power Company recently put into operation, two turbo generators of 35,000-kv-a. each were installed. In the Martin Dam plant of Alabama

Power Company, three 37,500-kv-a. units were installed for an average head of 120 ft. At Jordan Dam (Lock 18) now under construction, four 29,000-kv-a. units, operating at 93 ft. head are being installed.

When the new Gorgas steam plant of the Alabama Power Company was under discussion, very careful studies were made and 66,667-kv-a. units finally decided upon as the most economical size for our conditions. This plant, when completed, will probably be the most economical plant in the southeastern states.

This plant shows plainly the rapid change in conditions in a few years, indicating the prime importance of careful study of load growth and of consideration of the improvement in efficiency of steam units. Whereas 11 years ago the first large unit installed at Gorgas was 25,000-kv-a., and the plant was built purely as a reserve steam plant to operate at from 10 to 25 per cent annual load factor, the new plant will be a base-load plant, operating on a 50 per cent annual load factor at first, and probably ultimately on a 70 per cent load factor. Another interesting fact is that while the new plant will be 50 per cent more efficient than the old, its cost per kw. will be but little if any higher; such is the effect of larger units. Again, units of 66,667 kv-a. would not be the proper size were there not ample reliable tie lines between Alabama and Georgia so that such a unit would be available to both companies.

In present day practise, all substations are of the outdoor type with steel girders or steel pole supporting structures. They are simple and sturdy with large clearances. Small control houses are built for the relay, protective, and control equipment and telephones, with a small storage space for spare parts that must be housed. In older substations, the low-voltage buses and switches were put indoors; now, for 11,000 volts or above, nearly all are placed outdoors.

Double-circuit 110,000-volt lines, and many single-circuit lines, are built on steel towers but the majority of single-circuit 110,000-volt lines are of the familiar H-frame wood-pole type with one or two ground wires and the structures guyed at frequent intervals. Chestnut, juniper, and cypress poles are frequently used, but by far the greater number of lines are constructed with creosoted long-leaf yellow pine poles. These make a fine looking, long lived, low maintenance cost line.

By far the greater part of the territory served in the southeastern states is sparsely settled, with nothing like the density of load per sq. mi. that is encountered in the northeast or middle west. Therefore, types of construction which peculiarly suit these conditions have been developed. First cost must be kept at a minimum and at the same time, operation and maintenance must be kept very low.

Transmission lines still constitute the weakest link in the chain between generating station and customer. The question of ground wires is still a mooted one, but the majority of southern operators, after 15 or 20 years' experience, feel sure that they are justified on important lines and afford material protection against lightning. The new 154-kv. lines being built in Alabama and Georgia are being over-insulated, but the equipment is not. For its protection, a week link will be put in the lines near the substations by leaving off two or three of the insulator disks. On the question of high-voltage lightning arresters, opinion is much divided. On the Southeastern Power and Light Co. system we feel that in the more important stations the transformers should be given the benefit of doubt and arresters installed. Routine annual testing of transmission line insulators is now carried out by most companies. Some use a megger, but the majority use the buzz-stick method. This has proved very satisfactory in eliminating defective insulators. Between the improvements in design and the elimination of defectives by various tests, the number of insulators punctured or destroyed by lightning are very few,—nothing like the number we lost 10 years ago. It is still the general practise to patrol lines on foot with emergency patrol at regular intervals after every interruption.

With the growth and interconnection of systems, the necessity of uninterrupted communication circuits have grown in importance. Important stations and load dispatching centers are usually coupled by several private land-line circuits as well as by Bell system lines wherever possible. In the last two years extensive use has been made of the carrier-current telephone system, and exceptionally good results have been obtained. On the Southeastern Power and Light Co. system carrier-current sets are now being installed in Atlanta and Birmingham in the load dispatchers' offices to permit immediate communication between load dispatchers on the two systems; also, for the purpose of intercompany commercial calls. They are being used regularly for load dispatching on over 1000 mi. of transmission lines. For 75 days an accurate check was kept of the calls and 86 per cent of them were completed. Failure to complete most of the remaining calls was due to the operator called being where he could not hear the signals.

Oil circuit breakers continue to be one of the most important factors affecting satisfactory long distance transmission and system interconnection. Here, again, the increase in capacity of transmission lines and the concentration of power necessitate ever increasing capacity in the oil circuit breaker. Today, short circuits of 1,000,000 kv-a. are possible in the Birmingham District Substation and of 750,000 kv-a. at Atlanta. The additional tie lines between Alabama and Georgia will cause a complete change in 110-kv. oil switches in all of the Atlanta District oil switches. The general layout of the Southeastern Power and Light Co. system is such that we believe we shall continue to give best service by operating on so-called solid ties as compared to the loose link method, and limiting short circuits by opening it up at certain predetermined

points. Later, we shall probably add 110-kv. reactors through which normally no current flows. In contrast to this, the Southern Power system operates to much better advantage on the loose-link coupling.

To summarize, the past four years has witnessed a growth by all utilities in the southeast. Additional and higher capacity interconnectins have been made. Individual system operation has been improved, as has coordination between systems. More use is being made of interchange facilities. More careful forecasts of load growth are being made and more careful system planning to handle such growth is being done. Advantage is being taken of the lower costs of larger units and particularly of the improvement in efficiency of the modern steam generating plants. Long distance transmission is growing more reliable.

But there are still many problems unsolved, or only partially solved. Load dispatching grows more difficult and complicated with the growth of systems. From the standpoint of protection to service, proper relaying will continue to require much study. The division of load between parallel circuits, the control of wattless current, system stability, and more reliable oil circuit breakers, are problems worthy of the best engineering brains in the industry. As hydroelectric station decrease in size, more automatic ones will be constructed to keep down the cost per kw-hr. The future will probably see still larger steam plants with larger units located at the mine mouth, when water is available there, and others as near to large load centers as available condensing water will permit. These will, in turn, bring up the problems of still heavier main trunk transmission lines operated at higher voltages than at present generally used in the southeast. The last word has not yet been said regarding lightning protection. Improvement in communication circuits also offers a fertile field for study.

If the record of the industry for continued reduction in cost per kw. and per kw-hr. is to be maintained and, at the same time, the service carried farther and farther afield to thinner and thinner territory, there is no danger of our engineers running out of work.

Abridgment of

Quantitative Mechanical Analysis of Power System Transient Disturbances

BY R. C. BERGVALL[1]
Associate, A. I. E. E.

and

P. H. ROBINSON[1]
Non-member

Synoysis.—*The fundamental mathematical methods for calculating system transients have been presented by other writers during the last few years. These mathematical calculations are of necessity quite involved and consequently can be applied only to very simple power systems.*

In the May 1926 issue of the Electric Journal, under the title "A Mechanical Analogy to the Problem of Transmission Stability," Mr. S. B. Griscom proposed the use of an accurate equivalent mechanical analogy to the electrical system provided perfect springs for representing line reactance could be obtained.

The present paper covers the adaptation of the mechanical model principles to obtain reasonably accurate quantitative records of transients to be expected on the 220-kv. interconnection between the Philadelphia Electric Co., Pennsylvania Power & Light Co., and the Public Service Electric & Gas Co. These records are obtained by taking motion pictures of the equivalent mechanical system. Resistance or reactance short circuits on transmission lines are duplicated mechanically by applying forces of the proper magnitude and direction to the spring representing the line in trouble, and clearing this spring at each end by blowing fusible links from relays timed to represent the circuit breaker operations on the electrical system.

Fundamental Principles of the Mechanical Analogy to the Electrical System

THE analogy between the various parts of the electrical system and the equivalent mechanical system are shown in Fig. 1, which represents a single generator and its load tied together by the system reactance. The model consists of a generator element and a motor element, mounted on ball bearings and free to rotate independent of each other. For the present, the fault element should be neglected. The rotors have inertia proportional to the stored energy in the generators and loads which they represent.

Conversion of Electrical System into Mechanical Equivalent

The first step is to determine the characteristics of the springs which are to represent reactance. Consider that it is desired to select a spring of 10 per cent reactance on a 100,000-kv-a. base. In the electrical system, the 10 per cent on the 100,000-kv-a. reactance tie with 100 per cent voltage at each end, will correspond to a steady-state pull-out limit of

$$\frac{100 \text{ per cent}}{10 \text{ per cent}} \times 100{,}000 = 1{,}000{,}000 \text{ kw.} \quad (1)$$

1. Both General Engineers, Westinghouse Elec. and Mfg. Co., East Pittsburgh, Pa.

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The corresponding pull-out torque T of the mechanical model should then be obtained by gradually adding equal weights to the generator and load elements until the steady-state pull-out at 90 deg. between arms is obtained with the spring which is to represent 10 per cent reactance connected to each arm L inches (representing 100 per cent system voltage) from the pivot. This torque T (in ounce-inches) is then equivalent to

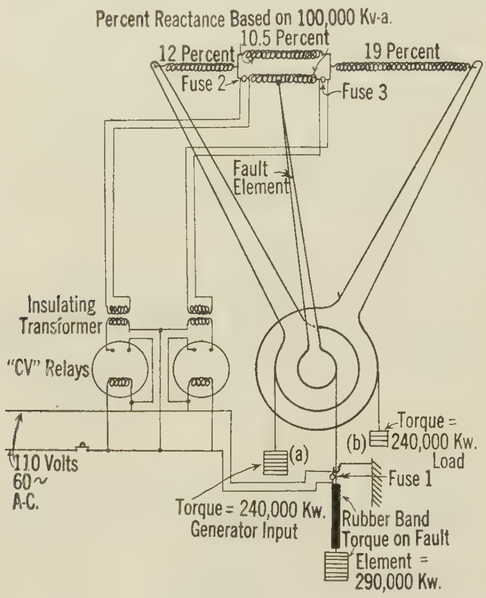


FIG. 1

Mechanical Analogy	Transmission System
1. Stiffness of spring.	1. Reactance represented.
2. Length of spring.	2. Voltage drop across reactance represented by spring. It is proportional to line current.
3. Counterclockwise torque applied by weight to any element	3. Represents kilowatts generator input to system at that point on system.
4. Clockwise torque applied by weight to any element.	4. Represents kilowatts load taken from system at that point.
5. Radial distance from pivot to any point on spring.	5. Line voltage at corresponding point.
6. Product of length of arm and component of spring tension along radius.	6. Reactive Kv-a.
7. Angle between any two points on the spring.	7. Electrical phase displacement of voltages at corresponding points of the system.
8. Inertia of any element.	8. Stored energy at synchronous speed in machines constituting corresponding element of electrical system.

1,000,000 kw. on the electrical system. The springs representing the reactances of the other parts of the system are then proportioned, taking the above spring as a base.

The stored energy in a synchronous machine =

$$E = \frac{2.3\ (W\ R^2)\ (\text{rev. per min.})^2}{10^7}\ \text{kw.-seconds at}$$

synchronous speed.

($W\ R^2$ is in pounds-feet squared) (2)

The total stored energy E at synchronous speed in the machines constituting any particular element of the system may be converted into inertia of the corresponding mechanical model element as follows:

$$W_1\, r_1^2 = \frac{E \times T \times 2.05}{10^6}\ \text{ounce-inches squared.}$$

E = Stored energy in synchronous machines in kw. seconds.

T = Ounce-inches of torque on model at steady-state pull-out with 10 per cent reactance spring attached to each arm L inches (equals 100 per cent voltage) from pivot. (3)

After determining the spring constant and the inertia in the foregoing manner, it can readily be shown that the natural period of any given element of the electrical system and the corresponding element of the mechanical system are identical.

The above discussion applies directly to all conditions imposing symmetrical loads on the different phases. For fault conditions, the electrical load may be unsymmetrical; *e. g.*, the fault usually is from one-phase wire to ground. From the stability standpoint, however, a single-phase fault on a polyphase system may be represented accurately by an equivalent symmetrical shunt impedance across the three phases at the point of fault.

MECHANICAL MODEL ON TWO-ELEMENT SYSTEM

Fig. 3-A shows two generating stations, each supplying some local load and tied together by two transmission lines.

In setting up a complicated system the number of elements must necessarily be kept down to a minimum in order to reduce the possibility of interference between springs. It is desirable, therefore, to combine the inertia of the local load with that of the local generating station into a single element on the mechanical model. Except for the phase angle which it produces in the

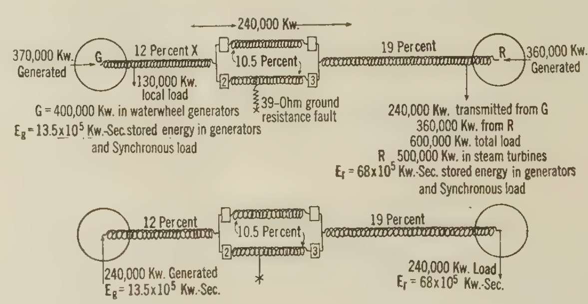


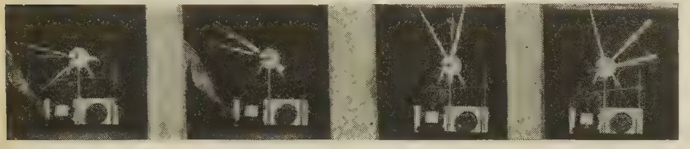
FIG. 3—(SEE FIG. 1 FOR SET-UP ON MECHANICAL MODEL)

generator, the local load has no effect on the over-all phase angles of the system. The simplied system used in setting up the mechanical model and calculating the curves which follow is shown in Fig. 3-B. By combining the load with the generator element, the system has been simplified to only two elements on the mechanical model. Disturbances on such a comparatively simple system can readily be calculated by a point-by-point method for comparison with the test results from the mechanical model.

Fig. 1 shows the mechanical model set-up of the above

system. The fault has been assumed to be single-phase line-to-ground, with 39 ohms resistance in the ground circuit with a resultant loss of 290,000 kw. The power in the fault was converted into equivalent ounce-inches of torque on the mechanical model, and this torque was suddenly applied to the transmission line on which the fault occurred by means of a very light rotating "fault arm" mounted on a ball bearing. The two ends of the spring representing the line in trouble are tied into the remainder of the system through fusible links which represent the circuit breakers at each end of line 2-3 (Fig. 3-B). The *C V* relays are timed to blow these fuses in the same sequence as the circuit breakers would clear the fault on the actual system. If the disturbance is not sufficiently severe to cause pull-out, the system will oscillate and finally assume a new stable angle corresponding to that when transmitting 240,000 kw., with only one line in service.

By referring to the schematic diagram in Fig. 1, it can be seen that the fault is applied by releasing the weight attached to the fault arm through the blowing of fuse No. 1 immediately after the pushbutton is closed. The closing of this push-button also starts the



a b c d

FIG. 6—EXTRACTS FROM MOTION PICTURES OF 290,000-KW. FAULT ON SYSTEM BY FIGS. 1 AND 3

a. Mount after fuse No. 1 (Fig. 1) is blown, releasing fault arm.
b. 0.25 sec. after fault. Note the decrease in angle.
c. 0.60 sec. after fault. Fuses No. 2 and 3 (Fig. 1) beginning to clear the spring which is attached to the fault arm.
d. 0.75 sec. after fault. Fault arm with spring 2-3 attached to it, has been cleared from the system
For curves plotted from the motion picture record, see Fig. 5

C V relays so as to blow fuses No. 2 and No. 3 in the proper sequence.

In some cases where the fault resistance is low, the positive sequence voltage, which is the voltage represented on the model, will dip to about 67 per cent of normal at the point of fault. In such cases an additional spring was used at the top of the fault arm and released simultaneously with the fault arm, so that the positive sequence voltage would be pulled down to this value.

Fig. 6 shows extracts from the motion picture film of the mechanical model with the equivalent of a 290,000-kw. line-to-ground fault applied to the system shown in Fig. 3-A. The oscillations of the system can be plotted from the motion picture record.

Because of the lesser stored energy at *G*, the torque of the fault tends to slow the generator down faster than the load end of the system *R*; therefore for the first four-tenths of a second, there is actually a decrease in the angle. Both breakers (fuses) were assumed to clear simultaneously in 0.65 sec. This is exactly simulated on the mechanical system by blowing the fusible links No. 2 and No. 3 in 0.65 sec. It should be noted that the breaker cleared at a point where the angle was considerably less than the final stable angle, with one section of line out so that considerable over-shooting will result.

MECHANICAL MODEL SET-UP OF INTERCONNECTED SYSTEM

Fig. 9 shows the 220-kv. interconnection between the Philadelphia Electric Co., Pennsylvania Power &

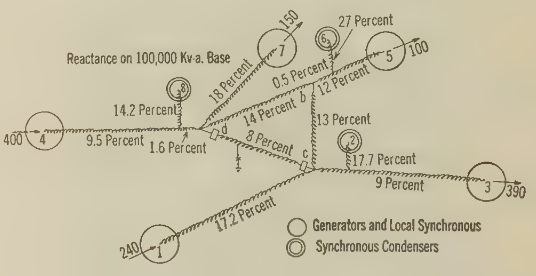


FIG. 9—ARROWS INDICATE THOUSANDS OF KW. ENTERING AND LEAVING NETWORK

' Stored Energy of Each Element in Kw-Sec
1. Conowingo 7.56 $\times 10^5$
2. Plymouth Meeting 2.2 $\times 10^5$
3. Phil. Elec. Co., 32.5 $\times 10^5$
4. P. P. & L. Sunbury 78.0 $\times 10^5$
5. Public Service Co. 91.0 $\times 10^5$
6. Livingstone 1.5 $\times 10^5$
7. Frackville & Siegfried 66 kv. load 39 $\times 10^5$
8. Siegfried & Frackville Condensers 4.1 $\times 10^5$

Light Co., and the Public Service Electric & Gas Co. reduced to a simple form for setting up on the mechanical model in the same manner as Fig. 3-B was obtained from Fig. 3-A. This figure shows one of the probable future load conditions. The loads supplied local to each generating station are not shown, as they produce very little affect on the phase-angular relations of the interconnected system. Only the transmitted power is shown.

The inertias of the various elements were properly proportioned by hanging equal masses across the elements that required additional inertia. For convenience, these masses were made of tubes that could be loaded with shot. Fig. 10 shows the Fig. 9 system as actually set up on the mechanical model.

With the load and springs properly proportioned, the phase angles between the various component parts of the system assumed their proper relationships automatically. The phase angles shown in Fig. 10 correspond very closely to the calculated values. For the set-up shown, the load conditions were such that practically no power was being transmitted over the section of the triangle *B-C* in Fig. 9. Fig. 10 shows this to be true. It can readily be seen that a fault on line *A-C* will be the most severe condition, since the power must be transmitted over the single lines *A-B* and *B-C* after the faulty section *A-C* is tripped out.

Analysis of Fault on Line *A-B* Fig. 9 from Motion Picture Record of Equivalent Mechanical Model

Condition No. 1. A line-to-ground short circuit on line *A-C* near end *A* having resistance equal to the reactance to the point of fault was considered. This gave the maximum possible kw. loss in the fault and

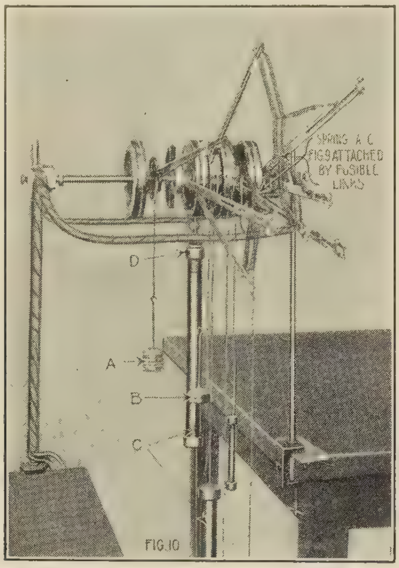
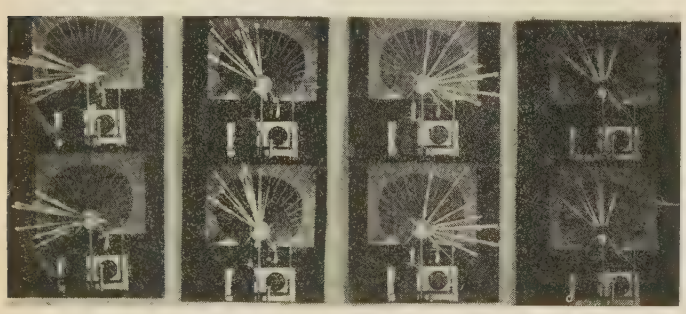


Fig. 10—For Diagram of System see Fig. 9

A. Weight producing torque tending to rotate element (1) counter-clockwise, representing 120,000 kw. generated.
B. Weight producing torque tending to rotate element (3) clockwise, representing 195,000 kw. load. This weight is at greater radius than (A) accounting for the smaller weight
C. Tubes of equal mass suspended over element (4) to increase its inertia from 32.5 (element alone) to 78 as required by tabulation on Fig. 9
D. Load weights (partly obscured) representing 200,000 kw. being generated by station (4)



a b c d

Fig. 13—Condition No. 1
Extracts from Motion Pictures of 450,000-Kw. Fault on System Shown by Fig. 9

a. Conditions at start of fault
b. Fuses (a) and (c) clear practically at the same time
c. Maximum angular swing between 3 and 4
d. Steady state operating condition with line A-c. out of service

amounted to about 450,000 kw. for the system shown. The torque representing this kw. loss in the fault was applied to the spring by means of the very light rotating fault arm shown in Fig. 13a. The function of this arm can be seen more readily from Fig. 1. The spring representing line *A-C* was attached to the remainder of the system by means of fusible links arranged to be blown by *C V* relays in order to duplicate the actual opening of the circuit breakers on the system. Fig. 13a shows two successive pictures at the instant of the application of the fault. The rapid movement of the torque arm is evident, since the pictures are only 0.05 sec. apart.

A cycle counter was included in the field of vision of the motion picture camera as a check on the speed of the film. Breakers *A* and *C* cleared the line simultane-

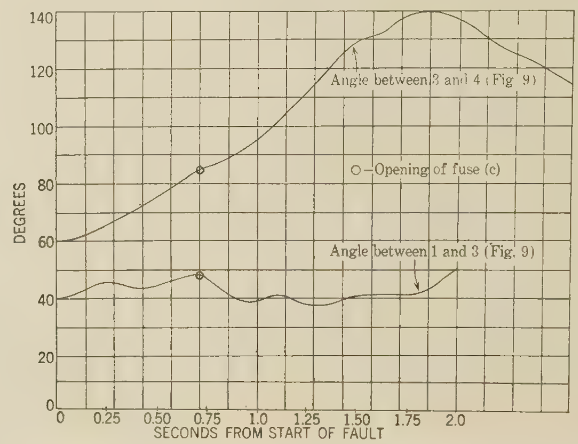
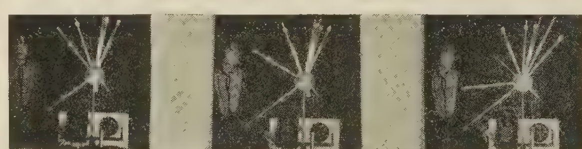


Fig. 15—Condition No. 3—Zero Resistance Line to Neutral Fault Near (a) Fig. 9

ously. The two successive exposures in Fig. 13b show the released fault arm with the spring *A-C* attached to it swinging clear of the system.

Fig. 13c shows the crest of the maximum angle between elements 3 and 4. The torque arm with spring *A-B* attached is shown against the stop.

After reaching the maximum angular separation,



a b c

Fig. 16—Condition No. 3
Extracts from Motion Pictures of Zero Resistance Line to Neutral Fault at (a) Fig. 9

a. Instant after fault was released, depressing the voltage at (a) to about 66 per cent normal
b. Instant after fuse (c) opened
c. Maximum angular swing between 3 and 4

the stations will oscillate and gradually settle at the new stable position with one line out of service, as pull-out did not occur.

Condition No. 3. This condition represents a line-to-ground fault on line *A-C* (Fig. 9) near (*A*) with zero resistance in the fault. The positive sequence voltage at the point of fault will be reduced to about 67 per cent of normal. This was represented by attaching a spring near the end (*A*) which could be released by the blowing of a fusible link to depress the springs representing line reactance to correspond to 67 per cent voltage

without applying any torque (kw.) to the system. For convenience, this spring was attached to the fault arm.

Fig. 15 shows the angular change between the extreme ends of the system plotted against time as taken from the motion picture record. Fig. 16a shows the initial condition a moment after the voltage at (A) was depressed to about 67 per cent of normal. Fig. 16b shows conditions at the instant the fusible link representing breaker C, cleared. The fuse representing breaker A failed to clear and Fig 16c shows the angular relation existing when stations No. 3 and No. 4 were at their extreme angular displacement. With the internal voltages in the generators maintained, the system will not pull out of step even though breaker A fails to clear the fault. This may be ascertained from Fig. 15 since the maximum angle of 140 deg. between stations No. 3 and No. 4 did not cause pull-out, and they are swinging back toward a smaller angle. The advantage gained by the use of high-speed excitation, which in so far as practical, maintains the internal voltage in the generators, is evident from an inspection of Fig. 16c.

Abridgment of

Automatic Switching of Incoming Lines and Transformers Supplying Power to A-C. Substations

BY A. E. ANDERSON[1]

Synopsis.—The early applications of automatic switching were confined principally to equipment which supplied or handled the outgoing power, such as conversion apparatus and outgoing feeders. As the field broadened and the capacity of the stations increased it became necessary to provide for greater continuity of incoming power. In order to meet this requirement it has been customary to bring two, and occasionally three, incoming lines.

It is the purpose of this paper to describe briefly some of the more common forms of this type of automatic switching. By making a few minor modifications of the schemes which are described it has been possible to automatically control a complete loop or ring system.

Balanced power or parallel incoming lines are quite common. Ordinarily two such lines are used, although as many as six have been contemplated. All lines are usually carrying power to the substation unless a fault has developed. When cleared of the fault, the line (or lines) is automatically replaced in service.

In case of the preferred—emergency—type of equipment, it is customary for one line (the preferred) to carry the substation load. The second line (emergency or standby) takes this load upon failure of the first line. The application of these units to a system usually determines the sequence of operation between the two lines. A few typical combinations are described and illustrated.

A brief description of automatic synchronizing and transformer switching has been included.

Introduction

At present a total load of over 500,000 kv-a. is being cared for by the equipments covered by this paper. The voltages range from 2.3 to 132 kv., while the capacity per substations so controlled averages approximately 5000 kv-a., the lower limit being 1000 kv-a. and the upper slightly in excess of 25,000 kv-a. It is felt that the application of these equipments will be greatly increased in the future. There are many substations at present being fed by one incoming line. Extension of the system in the future, and perhaps, in addition, the increasing importance of the load supplied by such stations may result in connecting these stations to another nearby line, or lines. Again, a new or existing station may be called upon to supply a type of load where continuity of service is of primary consideration. It is not the purpose of this paper to cover the various system protective features, since this is a subject in itself. Attention will be given to the operations performed by the automatic control from the point of the individual installation rather than the system in general.

The customary solution is to bring in another source of power through a second and sometimes a third incoming line. The use of two incoming lines for such installations is quite common. Another example of this type of equipment is in the automatic control of loop or ring systems, which, at times, require automatic synchronizing in addition to the usual control. Automatic supervisory equipment is sometimes used in conjunction with this form of control.

Balanced Power or Parallel Incoming Lines

A very common form of incoming lines are the parallel or balanced power as illustrated in Fig. 1. This type of substation is fed from the same generating station by means of two lines of practically equal impedance. In case of a current unbalance, as caused by a fault on one line, the oil circuit breaker feeding this line from the generating station is tripped as well as the corresponding breaker at the substation.

The substation breakers reclose only when three-phase voltage has been established on the incoming line for a definite time. This means that the corresponding generating station breaker must be reclosed

1. Switchboard Engg. Dept., General Electric Co., Philadelphia, Pa.

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either manually or automatically and attempt to re-establish service on the line. In case of short circuit conditions, only a few such attempts are made and consequently, the substation breaker does not reclose. In this manner, the brunt of the overload duty is thrown on the generating station breaker.

The three-phase voltage indication for a definite time shows that the fault has been removed and the line clear. The time delay is used in order to permit any protective relays to operate before the substation breaker is closed.

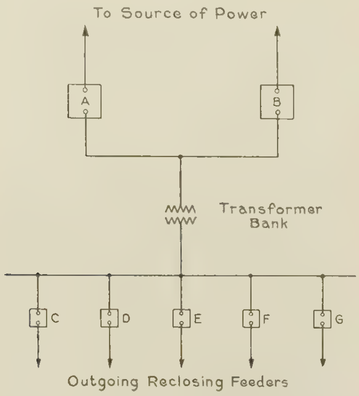

Fig. 1—One Line Diagram. Two-Balanced Power or Parallel Incoming Lines

Normally, both A and B are closed. A or B trip on unbalanced power and reclose on voltage restoration.

Preferred-Emergency Incoming Lines from Synchronous Sources

This type of equipment may be considered as a modification of that just described. Due to the fact that the two incoming lines, (Fig. 2), are of different impedance, enough current unbalance might be obtained to operate any protective relay if both breakers, A and B, were closed for any appreciable time. In addition, any connected load on these lines may require that both lines be normally disconnected from each other. Consequently the load at this substation is normally supplied from one line called the preferred or normal. The other line, called the emergency or standby, is used only in case it is in good condition and voltage has failed on the preferred line. Upon a loss of voltage on the preferred line, with suitable voltage on the emergency line, first the preferred breaker is tripped, followed by the closing of the emergency breaker. In making the retransfer from the emergency to the preferred line, with suitable voltage conditions on both lines, both breakers are closed for a short time. This temporary overlap is so short that protective relays will not operate, and result in a retransfer without dropping the load. The choice as to which line is the preferred or emergency depends on local conditions, and can readily be made by a transfer switch.

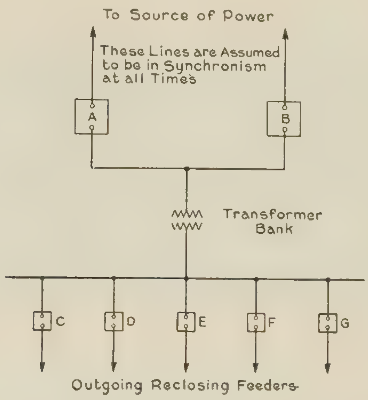

Fig. 2—One Line Diagram. Two Preferred-Emergency Incoming Lines From Synchronous Sources

Normally, either A or B is closed, and trips on voltage failure, provided voltage conditions are proper on the other (emergency) line. Restoration of voltage to the preferred line results in retransfer of the load to that line. Under certain conditions A and B may be closed simultaneously for a short interval. Either line may be made the preferred

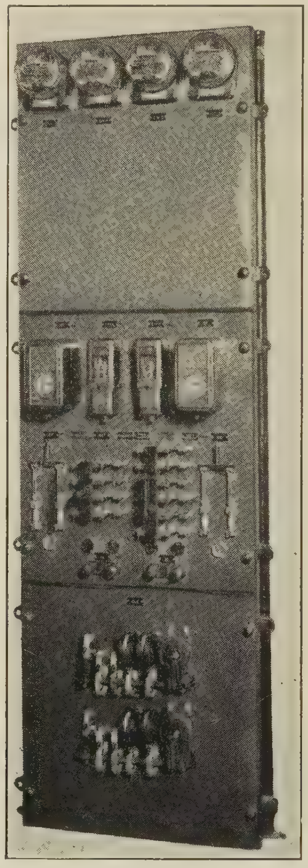

Fig. 3—Panel-Mounted Devices for Controlling Preferred-Emergency Incoming Lines From Synchronous or Non-Synchronous Sources, as Well as for Controlling Non-Preferential Incoming Lines

This type of equipment, as illustrated in Fig. 3, is usually furnished with two transfer switches. One is used to select the "preferred" and "emergency" sources from the two incoming lines. The other is used to enable the equipment to be operated entirely automatically or entirely manually. These two latter functions are kept independent of each other.

Preferred-Emergency Incoming Lines From Non-Synchronous Sources

This type of equipment may be considered as a modification of that described above and is used where the two incoming lines are assumed to be out of synchronism at all times. Therefore, one breaker must be opened before the other breaker can close. If this is not done, then the incoming line equipment will connect two generating stations which may be out of synchronism. Either line may be made the preferred as explained above.

Undervoltage conditions for a predetermined time will cause the preferred breaker to be tripped by voltage from the emergency line after which the emergency breaker is closed. A return of voltage to the preferred line, will cause the emergency breaker, after a time delay to be tripped and the preferred breaker to be closed.

Partial Automatic Preferred-Emergency Incoming Lines

A limited form of incoming line equipment is obtained by using one manually operated and one motor-operated breaker. The manually operated breaker is connected to the preferred line while the motor-operated breaker is connected to the emergency line.

Upon failure of voltage on the preferred line, its breaker is tripped, after which the emergency breaker is closed. The equipment remains in this position until the retransfer is made, manually.

A disadvantage of this type is that the emergency line may subsequently fail with its breaker closed and voltage return to the preferred source. Since the preferred breaker is manually operated, it is necessary to wait for the arrival of the operator or inspector to effect the retransfer.

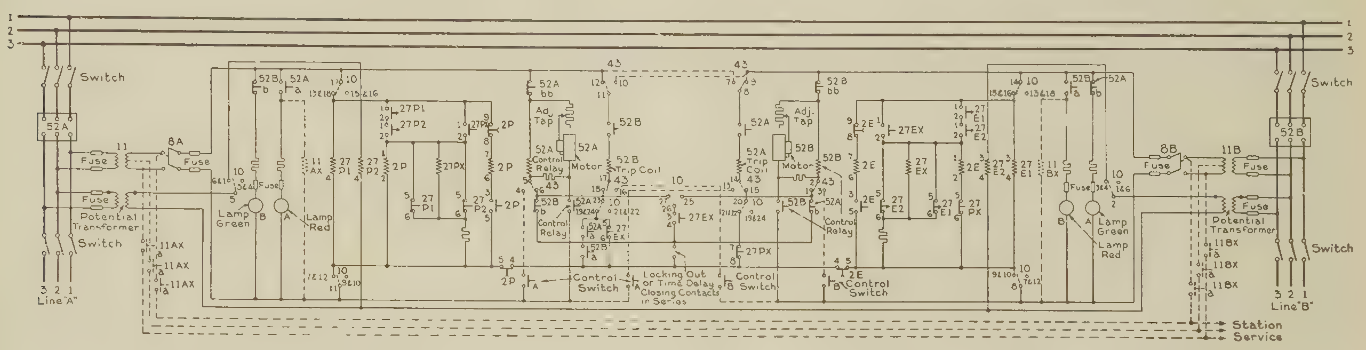

Fig. 4—Elementary Diagram for Two Preferred-Emergency Incoming Lines From Synchronous Sources

No attempt is made to go from one line to the other unless the line to which the transfer is to be made is in better than, or as good condition as, the one that has been supplying power previously.

Non-Preferntial Incoming Lines

At times, it has been found advisable to allow either incoming line to feed the load as long as proper voltage conditions exist on its line regardless of conditions on the other line. If voltage fails on this line and conditions are satisfactory on the other, then its breaker will trip, and the other close. The other line continues to feed power to the load regardless of a return of voltage to the first line.

Due to the fact that one breaker is always open before the other can close, these equipments may be connected to synchronous or non-synchronous sources.

Combined Reclosing and Preferred-Emergency Incoming Lines

Another common application is one in which two preferred-emergency incoming lines supply only one outgoing feeder. Overload protection is provided so as to trip whichever breaker is closed. If overload conditions persist, a certain number of reclosures is permitted, after which, the equipment is locked out.

Automatic Substations Supplied by More Than Two Incoming Lines

Fig. 4 shows a one-line diagram of an automatic station that is supplied by a number of incoming lines with their respective transformer banks. Line *A* and its associated transformer are for emergency and take the place of any line or transformers that have failed. Lines *B*, *C*, and *D* are the normal sources of power.

Normally, line *D* and its associated transformer feed the low-voltage bus sections, which are now tied together. Whenever sufficient load demand occurs, the second bank is brought on and the first bank carries only its section of the bus with its connected outgoing feeders. Continued load demand brings on the third bank with the same resulting connections. The low-voltage bus is now completely sectionalized and each incoming line feeds its share of the outgoing feeders direct from the generating source. This results in radial or stub feed direct from the source to the load and also in a simple relay protective scheme.

If any line or bank fails, it is taken out of service and replaced by the emergency line. The remaining lines (in good condition) feed their share of the load direct as in the case of switching under normal conditions. The relays make the proper set up, after which the panel-mounted drum controller completes the required

switching operation. The use of a drum controller for such equipment greatly decreases the number of contacts necessary on the relays and also results in a positive sequence of operation.

Automatic Transformer Load Responsive and Load Ratio Control Equipment

In the case of load responsive switching of transformer banks, one bank carries the substation load during light load periods. The second bank is connected when the load on any one phase increases to a predetermined value. When the load on all three phases decreases to another predetermined value, the second bank is disconnected.

The indication for bringing on or taking off the second bank is obtained from current transformers connected in the line. Where two or three power transformers are used, it is found advisable to parallel the current transformer secondary circuits and totalize the current on each phase. This permits the use of a fewer number of master relays with a resulting simplification of relay calibrations. If one set of relays is used for each bank it becomes necessary to provide a gap in the relay calibrations, in order to avoid having two sets of relays calling for opposite switching action.

Differential and thermal protection are ordinarily provided. Upon failure of one bank, it is immediately disconnected and locked out, the remaining bank then takes its place and no further load responsive switching is performed until the lock-out relay or relays are manually reset. This enables the equipment to be inspected and the cause of failure ascertained before the unit is replaced in service. Either bank maybe made the "leading" or "trailing" by means of a transfer switch.

Automatic switching equipment has been recently applied to transformer tap changing (under load).

To adjust the line voltage in accordance with the changing load, the high-voltage windings have eleven taps of 2½ per cent each. To permit a change of taps without interrupting the load, a part of the high-voltage winding is made in two sections, normally operating in parallel and dividing the load equally. Each of these winding halves is connected to an eleven-point ratio adjuster (Fig. 5), and the resulting circuits brought out of the transformer tank to two three-pole oil circuit breakers.

Consequently, it is possible during the tap-changing period to open-circuit one section in each phase, and change the voltage tap in this open-circuited section while the other section temporarily carries the entire load of the transformer.

Automatic Synchronizing of Incoming Lines

In general, there are two conditions under which an incoming line should be synchronized with the bus. One condition is where two sections of a system are already tied together at some other point. This means that the two voltages, at the open breaker terminals, are stationary with respect to each other, but may have a certain phase displacement due to circuit conditions.

In case two sections of a system are cut apart, it will be found that the two voltages, at the open breaker terminals will be rotating with respect to each other at a frequency equal to the frequency difference between the two generating stations. The equipment in the automatic substation, has no control over the governors in either generating station, so that the closing operation of the breaker is determined by other factors, which are, first, that the frequency differential must be less than a certain value and secondly, the breaker closing impulse must be given enough ahead of synchronism so as to enable the breaker to be closed when the point of synchronism is reached, in other words, at "12 o'clock."

The calibration of the synchronizing relays for the two different operating conditions is such that one is inoperative under conditions under which the other functions.

It has been found advisable to use a separate synchronizing relay combination for each breaker. Different breakers have different closing chracteristics, and even though a number of breakers could use a common synchronizing relay it has been found that the resulting scheme would be more complicated, less flexible, and more expensive than the individual control.

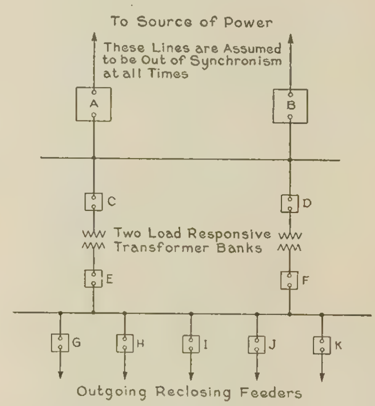

Fig. 5—One Line Diagram. Two Preferred-Emergency Incoming Lines From Non-Synchronous Sources

Normally, either A or B is closed, and trips on voltage failure, provided voltage conditions are proper on the other (emergency) line. Restoration of voltage to the preferred line results in a retransfer of the load to that line. Breakers A and B are not closed at the same time. Either line may be made the preferred.

Figure Designation in Abridgment	Corresponding Figure Designation in Complete Paper
1	1
2	2
3	3
4	9
5	10

Abridgment of

Metallic Arc Welding Electrodes

A Study of the Effects of Surface Materials

BY J. B. GREEN[1]

Non-member

Synopsis.—To understand the effect of surface materials on metallic arc welding electrodes, something must be known as regards the fundamental theory of arc heat distribution, arc vapor resistance and similar matters which are modified by the presence of surface materials. The character of the arc may be changed by chemical and structural variations in the surface materials. Stability is one such arc characteristic.

Two types of stability are recognized,—chemical and electrical. Surface materials have a significant influence on the brittleness or ductility of weld metal. They also can be used to control the arc type, four such types being recognized. The influence of surface materials on the heating of electrodes is another phase of the matter of practical significance. Surface materials may be employed to control both the operating characteristics of the electrode and the resultant weld properties. Among the operating characteristics might be mentioned stability and rate of melting. Among the weld properties are included freedom from blow-holes and tensile strength. These and other practical applications of a comprehensive knowledge of surface materials are cited in this paper.

* * * * *

SURFACE materials fundamentally, may vary chemically or structurally. Chemically, their variation is almost infinite and structurally; they may be coarsely or finely powdered or may be fibrous; they may be crystalline or amorphous; they may be applied evenly or unevenly, more on one side than the other, more at one end than the other or in single or multiple layers. Also, the relative mass of surface to electrode material may be varied.

Taking up first the chemistry of the surface materials, it is found that both the arc heat distribution and total arc heat may be influenced through this fundamental. The electrodes themselves are metallic; hence they are first-class electrical conductors. The surface materials are most commonly non-metallic and are therefore only second-class conductors. When the vapor of a second-class conductor predominates in the arc stream, the higher the temperature, the lower the resistance. This state of affairs tends to increase arc stability, since a given variation in arc length produces a lesser variation in resistance. The arc is complex and most observed tendencies are usually the algebraic sum of several tendencies. For example, an absolutely clean iron electrode operates with greatest stability when made the positive terminal of a d-c. generator because the thermocouple action is such that the preponderance of heat appears at the negative end of the arc stream. By applying an inappreciable coating of calcium hydroxide, this thermocouple action is reversed and the arc becomes less stable, although the surface material is a second class conductor. Reverse the direction of of the welding current and the stability is restored. Increase the quantity of the calcium hydroxide and the stability increases until the arc stream becomes saturated with the resultant vapor, after which further increase of stability ceases regardless of additions of the surface materials.

A welding rod was prepared to show the significance of surface materials as just indicated. The bottom or starting end of this electrode possessed no surface materials, the center had the residual wire-mill lubricants, which became essentially calcium carbonate by the time the electrode was used, and the top coated with

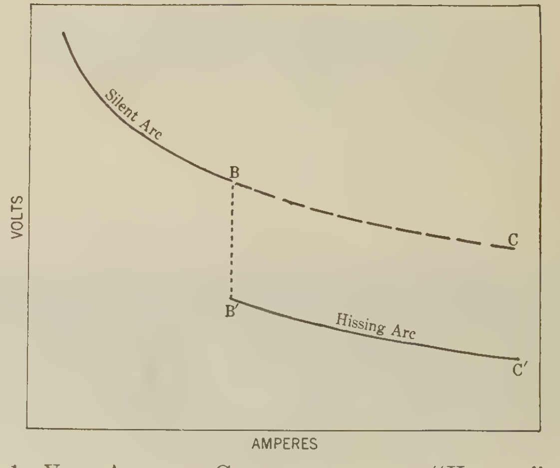

FIG. 1—VOLT-AMPERE CURVES OF THE "HISSING" AND "SILENT" ARCS

the usual commercial flux composed of calcium carbonate together with siliceous materials. As such an electrode is run with direct current, (regular polarity), the first third gives a very unstable arc, the middle third, an arc which is commercially acceptable, and the top third, a very stable arc. All this seems due to a combination of arc heat distribution and arc vapor resistance.

To better understand the effect of surface materials on arc stability something must be said of stability itself. This matter is quite complex, but broadly, there is electrical and chemical stability. As the arc

1. President, Fusion Welding Corporation, Chicago.

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length increases, its resistance goes up, the arc voltage rises and the current falls. It is inherently unstable. Therefore ballast resistance must be introduced in a constant potential source of supply current, or other stabilizing means be provided in a variable potential supply.

Chemical stability is no doubt due to violent chemical reactions taking place in the arc, usually between the electrode materials and surrounding atmosphere. It is well known that as the current is increased from zero,

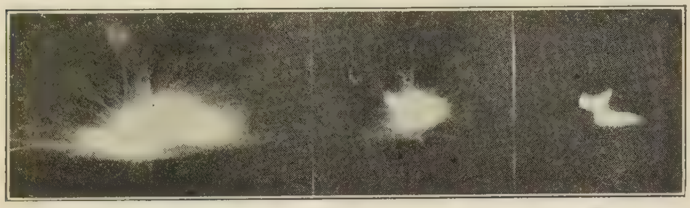

Fig. 2—Three Stages of the Transfer of a Single Drop of Molten Metal as It Takes Place in Metallic Arc Welding

the arc is at first silent, then the voltage drops, making a volt—ampere curve of seemingly hyperbolic form. This is shown in Fig. 1 from A to B. At B it drops suddenly and continues on in much the same form from B^1 to C^1. The arc, after passing the critical point B, hisses. This drop appears to be due to the introduction of the vapor of a second-class conductor, a product of chemical reaction, and this same chemical reation produces the hiss. If a hissing arc is surrounded with a chemically inert atmosphere, the hiss ceases and the arc voltage rises to values indicated on the line B-C.

In Fig. 2, is shown a picture of the welding arc taken

Fig. 3—Arcs with Three Types of Electrons

Left coated with thorium oxide
Center uncoated
Right coated with berylium oxide

with infra-red light showing three stages of the transfer of a single drop of metal in the metallic welding arc. In taking these photographs and others shown in this paper, a light filter was interposed between the arc and the plate, and this allowed substantially infra-red light only to reach the plate. At the left, in Fig. 2 the drop has reached maximum size and is about ready to capillary across to the deposit. Note that the drop is almost completely surrounded by the arc flame and, just prior, it was so surrounded. In the center, the drop has just touched the deposit metal. Note that the flame has disappeared and that a white hot, but still solid, collar is left on the end of the electrode. At the right the drop is about to neck off re-establishing the arc. The collar is still in evidence. This collar quite evidently represents the material receiving maximum contact with the surrounding atmosphere while at temperatures most apt to combine with the oxygen and nitrogen. An inert surface material which is fluid and tends to wet this white hot collar obviously protects it from contact with the surrounding atmosphere. Thorium oxide is such a material and a mild steel electrode coated with it gives an arc practically as silent as that between carbons.

In Fig. 3 this arc is shown at the left. Note the large size of the drop as compared with the one at the center from the same electrode uncoated. The electrode with thorium oxide permits the drop to form without being literally blown off before reaching

Fig. 4—Erratic Core Type Arc

maximum size by violent chemical action. At the right is an arc from the same electrode coated with berylium oxide. Note that this is smaller than that from the uncoated electrode at the center. The chemical action seems more violent and the drops are detached very rapidly. Each of these views were selected from several thousand pictures taken as representing the largest drop in each case.

These pictures lead to a few remarks on arc types, all of which may be produced by surface materials. At any certain current, every electrode tends to give some one of the four recognizable arc types. The one at the top is a steady core type while the one at the bottom is a sheath type; the hollow center of which cannot well be represented by photography. In the steady core type the arc tends to pull off the bottom center evading the upper edge of the drop. In Fig. 4 the reverse is true, an erratic core type arc being shown which tends to pull off only from the upper edge of the drop. This is a very difficult arc for the welder to handle. A saturated arc is shown in Fig. 5, the arc stream pulling off from the entire cross-section of the electrode. This is probably the most satisfactory arc

for the welder to handle. The sheath type is probably a special form of the erratic core type, or vice versa, the arc merely pulling off from all points of the upper edge of the drop at once. This leads to the conclusion that the different arc types are the resultant of the absolute resistance of the arc vapor stream and the relative resistance as between the central and outer portions. A steady core type arc often may be changed to a saturated type by merely increasing the current

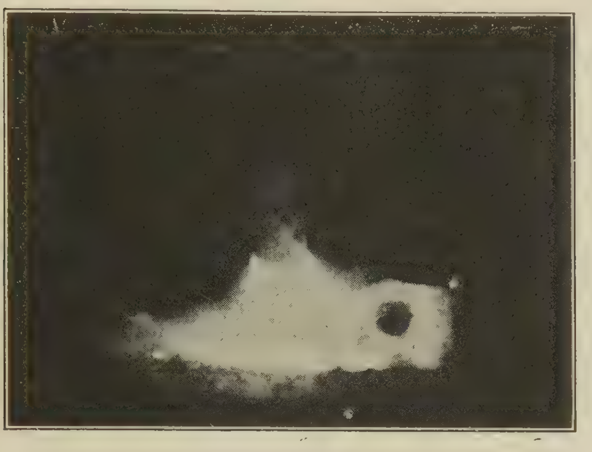

FIG. 5—SATURATED TYPE ARC

density. Some electrodes melt in their entirety on account of resistance heating before the current density is raised to the point that a saturated arc results.

The influence of surface materials on the heating of

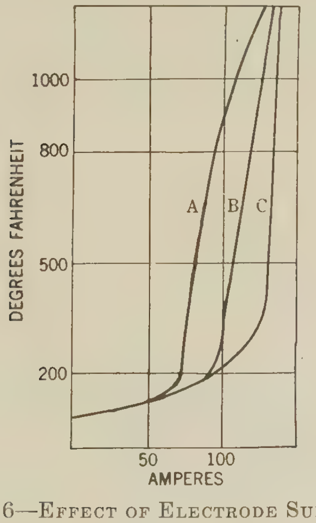

FIG. 6—EFFECT OF ELECTRODE SURFACE

A. Bare
B. Green surfaced
C. Polished

electrodes is another phase of the matter of practical significance. Most electrode heating is due to poor holder contact and so perfect contact must be assured in studying the effect of surface materials themselves in this respect. In Fig. 6 are shown the curves obtained by allowing the same electrode to reach equilibrium temperatures in the air at various currents, the surface only being varied for each curve. It will be noted that less current is required to heat what is known as a bare electrode as shown in Curve *A*, possessing only the residual wire mill lubricants as a coating, than the heavier coated green surface shown in Curve *B*, or the polished rod shown in Curve *C* which is free from all surface materials. Conversely, the green surface and polished rods will carry higher welding currents than the so called bare finish.

To most people the practical application of all this fundamental theory is the interesting thing. Both operating characteristics and weld properties may be controlled through the intelligent employment of surface materials applied to metallic arc welding electrodes. Possession of the handbook data on the subject permits deliberately designing an electrode for a specific purpose. Not many years ago, electrodes were developed by hit or miss experimenting and a use found for them after they were developed. Handbook data cannot very well be developed without a knowledge of the fundamental theory. It would be like trying to design structural members without a knowledge of moment of inertia, for example, which requires calculus to compute.

One of the earliest applications was in Europe where

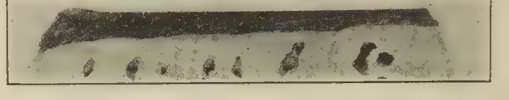

FIG. 7—LONGITUDINAL CROSS-SECTION OF A CHROMIUM STEEL METALLIC ARC WELD DEPOSIT USED TO STUDY BLOW-HOLES IN WELDS

alternating current is largely used for welding. The bare electrode seldom gives sufficient stability for a-c. welding as a commercial process and so slag or flux coated electrodes were developed. The welding of mild steel has become a production process subject to all the competition of other such processes. The electrode, therefore, must exactly fit the job. Every different set-up represents a different set of conditions to be met. Sometimes quality is involved. The weld must be free from blow-holes. These are the result of a race between the escaping gas and the solidifying metal in which the gas loses and is imprisoned in the weld. Fig. 7 shows the blow-holes in a piece of stainless steel. Such steel offers an excellent opportunity to study the subject of blow-holes because they are generally elongated and thus indicate their origin, their extent of travel and direction of travel. Through the proper use of surface materials on the electrode the distribution of arc heat may be controlled and the blow-holes held at the bottom of the weld, allowed to reach the center or the top, or to escape entirely leaving a sound weld.

Often oxides and nitrides are found in arc welds representing a content of 1 per cent in mild steel,

while all other elements, other than iron, are not over ½ per cent. Thus in determining the physical properties of the weld in so far as such properties depend on the chemical analysis of the deposited metal these oxides and nitrides are often the predominating factor. Surface materials may be used to protect the transferred metal so that the brittleness incident to the presence of oxides and nitrides is reduced or eliminated.

Again, competition may demand that welds be made at high rates of speed. For example, ½-in. plate welding has been done by beveling the edges and running three layers of weld metal, usually brushing and often caulking each layer as laid. For the highest quality work of this sort, three feet per hour per operator is good practise. By using the surfaced electrode developed in the author's laboratory, which alters the arc heat distribution, sound welds fuzing clear through a ½-in. plate have been made at a rate of over 20 ft. per hour on plates butted together without beveling and with one passage of the electrode.

These are only a few out of the very many practical applications of a knowledge of surface materials on metallic arc electrodes. Furthermore, the effect of surface materials is only one consideration of arc welding. Metallic arc phenomena are extremely complex and when used for welding, the complexity is tremendously increased. Knowledge of the subject is very far from complete and probably the greatest opportunity for future fundamental research lies in discovering adequate means for measuring the arc thermocouple voltages.

Dividing Load Economically Among Power Plants

by Use of the Kilowatt—Killowatt-Hour Curve

BY A. WILSTAM[1]

Associate, A. I. E. E.

FREQUENTLY, it becomes necessary for various reasons to study the relations between the output and the plant capacity of part of an electric system as distinguished from the whole capacity and the whole load. For example, it may be desired in a system of, say, 100,000-kw. capacity, to know how many kilowatt-hours will be absorbed by the load between the 50,000-kw. and 75,000-kw. loads, or how many kilowatt-hours lie below or above the 50,000-kw. line. One instance when such information is valuable is in estimating fuel cost for a year in the future. When operating steam plants where the system contains units of higher and lower fuel economies and where it is desired to get the greatest use out of the more efficient units and hold those of lower efficiencies for peak loads, the course can well be to forecast the output of each kind of plant and to predict the amount of fuel to be required by each.

If the utility generates electricity from both water and steam power, the importance of designating the right position in the load curve to the various power resources becomes paramount.

A utility may generate power from stream flow plants without water storage, where the daily power generated is rather constant. This power may be considered as base power, operating for 24 hr. Power generated from stored water in an up-to-date plant is easily regulated and may be governed to take most, if not all, of the daily variation of the load up to its capacity or water supply. Steam units of high efficiency may be operated at their best rated efficiency on block loads; and steam plants or units of lesser efficiency may be used to advantage on peak loads.

1. Electrical Engineer, Southern California Edison Company.

The Southern California Edison Company, operating a number of steam and water-power plants, some of which operate from stored water, has for a number of years given serious study to economical production and to a balanced proportion of steam and water power most suitable to conditions existing in central and southern California, and in order to meet the constantly growing power market, it has been compelled to program its operations years in advance. It was due to this effort that in 1916 a certain load curve was devised which has proven to be of great value in estimating future loads.

This curve is shown in Figs. 2, 3, 4 and 5.

It can be made to apply to either days, months or years, but the monthly curve is the one most suitable for general purposes.

The longer the period considered, the more accurate the curve will be.

Referring to the figures, Fig. No. 1 illustrates a daily system load curve, such as is usually plotted and kept by most of the power companies. From a curve of this kind, or from records from which it is made, the load curve particularly referred to in this article may be made up.

Fig. No. 2 is a reproduction of the first curve regularly made and kept in the files of the company and represents the load as of June 1917.

By examining the curve, it will be seen that the total output for the month was 62,000,000 kw-hr., the maximum peak 135,000 kw. and the minimum demand during the month 40,000 kw.

This load curve was made up from completed monthly records taken of the kilowatt readings at half-hour

intervals during the month of the total system load by the following method:

On a suitable cross-section paper which had previously been prepared by marking a horizontal scale to represent 1,000,000 kw-hr. and a vertical scale to represent kilowatts, see Fig. No. 2, make the distance on the horizontal line *A-B* equal to the output in kilowatt-hours for the month. From *B* draw a vertical line *B-D* to represent the kilowatt demand, point *D* being the maximum peak for the month. Locate a

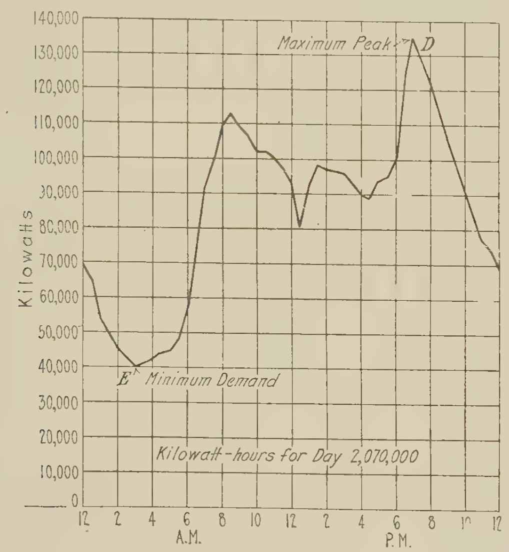

Fig. 1—Total Daily System Load, June 1917

point *C* on line *B-D* corresponding to a kilowatt demand at 100 per cent load factor. Connect *A* with *C*. Locate *E* on line *A-C*, this point representing the minimum demand in kilowatts for the month. From

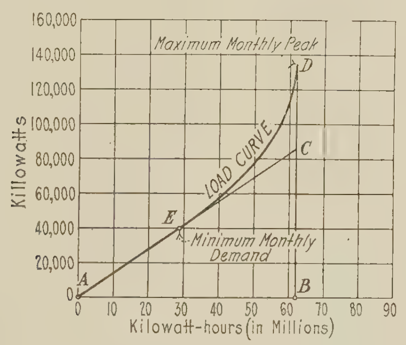

Fig. 2—Kilowatt—Kilowatt-Hour Curve, June 1917

E to *D*, finish the curve by plotting from the records of the hourly readings as indicated below.

At point *E*, see Figs. 1 and 2, the minimum monthly demand is shown to be 40,000 kw., being the lowest demand for the month, which means that 40,000 kw. has been maintained throughout the whole month or for all of the 720 hr. of the month, so the kilowatt-hours at this point are 720 × 40,000 = 28,800,000. This point *E* on the curve represents a load of 100 per cent load factor.

At a point indicated by, say, 80,000 kw., the area, see Fig. 1, between a line drawn horizontally through this point and a line drawn similarly through point *E*, at 40,000 kw., is found by compiling the hour or half-hour readings to contain 22,200,000 kw-hr. The total kilowatt-hours, therefore, at this point on the curve, as shown in Fig. 2, should be 28,800,000 + 22,200,000 = 51,000,000. The curve therefore, will

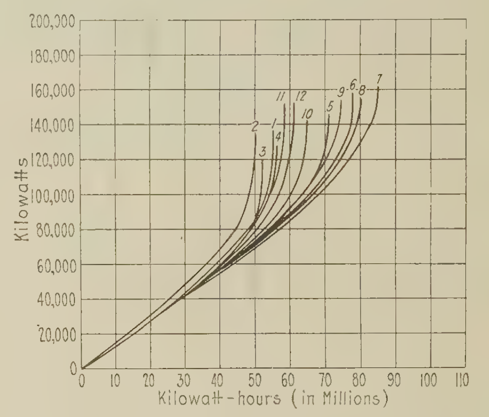

Fig. 3—Comparative Total Monthly System Load Curves for Year 1918 from Actual Plottings

Southern California Edison Co., Los Angeles, Calif.
Number of curves refer to consecutive months of the year

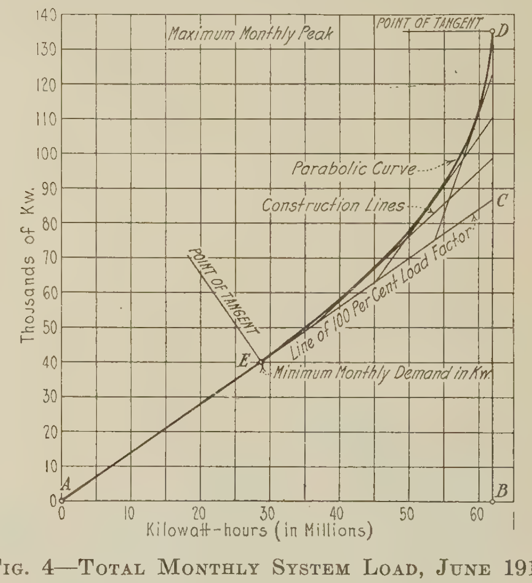

Fig. 4—Total Monthly System Load, June 1917

30 day month—720 hours., maximum peak 135,000 kw.
Output 62,000,000 kw-hr., load factor 64 per cent
Minimum demand 40,000 kw.

run through a point indicated by 80,000 kw. and 51,000,000 kw-hr. This point we will call *X*.

At a point indicated by 100,000 kw., the area between this point and point *X* is found as above outlined to contain 6,500,000 kw-hr. The total kilowatt-hours at this point are, therefore, 51,000,000 + 6,500,000 = 57,500,000. The curve, therefore, will run through a point indicated by 100,000 kw. and 57,500,000 kw-hr. This point we will call *Y*.

Point *D* as shown in Fig. 2 is indicative of the total kilowatt-hours and the maximum kilowatts for the month.

The curve, then, as plotted, can be drawn from *A* to *E* through points *X* and *Y* to *D*. The above, of course, indicates only the method; when actually making the curve, sufficient points should be taken and the curve made large enough for practical purposes.

This kind of curve was plotted from actual data in a laborious way for each month, commencing with June 1917 and going up to January 1923, when this method was discontinued, as it was found that when the kilowatt-hour output, maximum monthly peak and minimum monthly demand were known, a curve could be constructed in a few minutes, that was good enough for estimating purposes.

Fig. 3 shows in a comparable way the total monthly system load curves as plotted for year 1918.

Fig. 4 shows the monthly system load curve as now

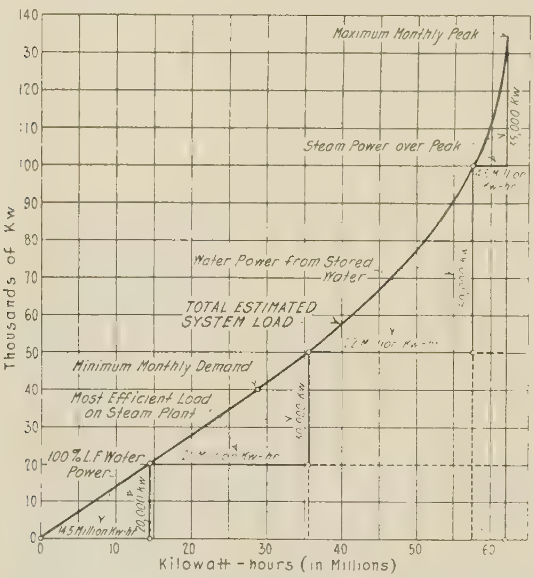

FIG. 5—APPLICATION OF RESOURCES TO ESTIMATED MONTHLY LOAD BY THE USE OF THE KILOWATT—KILOWATT-HOUR CURVE

being used. To construct this curve, the following three factors are necessary:

1. Monthly output in kilowatt-hours,
2. Maximum monthly peak in kilowatts,
3. Minimum demand in kilowatts during month.

How to Construct the Curve. Referring to Fig. 4, draw line *A-B*, equal to kilowatt hour output for the month. From *B* draw a vertical line *B-D*, equal to maximum demand in kilowatts for the month; locate *C* on line *B-D*, point *C* corresponding to the kilowatt demand for the month for 100 per cent load factor; connect *A* with *C*. Locate *E* on line *A-C*, this point being the minimum demand in kilowatts during the month. From *E* to *D* construct a parabolic curve with tangent points at *E* and *D* as shown. Then the curve *A-E-D* is the monthly load curve in question.

It will be seen from examining this chart that the breaking off from 100 per cent load factor occurs at *E*, in this particular case at 40,000 kw. and 28,800,000 kw-hr., and that the load factor beyond *E* varies from 100 per cent at *E* to zero at *D*.

How to Use the Load Curve. The primary purpose for which this curve was developed was to properly allocate the available resources to a future estimated load, so as to get the most from those resources with the least expense. Fig. 5 illustrates the application of resources to an estimated monthly load for a power company having both hydroelectric and steam plants. Referring to the figure, it will be seen that the allocation of the available resources is as follows:

	Kw-hr.	Kw.
Stream flow plant without storage at base of load, 100 per cent daily load factor	14,500,000	20,000
Most economical loading on high efficient steam plants or units	21,000,000	30,000
Water power from stored water up to plant capacity limited by the annual distribution of water supply	22,000,000	50,000
Steam power over peak	4,500,000	35,000
Total estimated monthly load	62,000,000	135,000

Of course, the above allocation is only illustrative. The curve and general method of loading are applicable to any resources or load, whether hydroelectric, hydroelectric and steam, or steam alone, having plants or units of different efficiencies.

MORE ILLUMINATED AIR MAIL ROUTES

According to a recent announcement, National Air Transport will extend its overnight mail and express routes into Tulsa, Okla., and into Detroit, as soon as the government can install the necessary lighting equipment. Representatives of the United States Department of Commerce are now engaged in making their survey and it is expected that operations will start over the new extensions within the next three months.

A novel lighting plan, adopted from river navigation lights, will be put into use on the 75-mile Ponca City-Tulsa extension. This plan has been worked out by government and air transport engineers in consultation with L. D. Seymour, Chief Engineer of National Air Transport. A thirty-foot steel tower will be erected approximately every three and one-half miles on the Tulsa line. On top of the tower will be mounted an acetylene-gas fixed or bulls-eye type of drum lamp equipped with eighteen-inch lenses throwing its beams in opposite directions along the course of the flight, Above the bulls-eye will be a dome-like acetylene blinker lamp of 15,000 candlepower, whose light will be visible to the flyer above at all degrees of the zenith, for a distance of several miles. The fixed, or bulls-eye lamps will be of 50,000 candlepower each and it is stated that they will be visible in clear weather at a distance of forty miles.—*Transactions, I. E. S.*

Abridgment of

Conowingo Hydroelectric Project
of The Philadelphia Electric Company System With Particular Reference to Interconnection

BY W. C. L. EGLIN[1]

Fellow, A. I. E. E.

Synopsis.—This paper discusses the interconnection between three of the leading power supply company's in the eastern part of the country, the Philadelphia Electric Co., the Pennsylvania Power & Light Co. and the Public Service Electric & Gas Co. It outlines the physical aspects of the tie-in between the companies which is a 220-kv. ring of high-load capacity, triangular in shape with sides respectively 49 mi., 82 mi., and 77 mi. long. The advantages of the interconnection are enumerated as well as some of the operating problems.

Preliminary to the discussion of the interconnection the paper discusses the Conowingo hydroelectric project, an important factor in the interconnection scheme. The plant has an initial installation of 280,000 kv-a. in generators.

* * * * *

As a sound basis for developing the relation between the Conowingo Project and the three-party interconnection agreement recently completed between The Philadelphia Electric Co., the Pennsylvania Power & Light Co., and the Public Service Electric & Gas Co., it seems advisable to begin by restating, briefly, the more important features of the Conowingo Project.

Conowingo Project—General

The Susquehanna River has an extremely variable flow, ranging from peaks of over 500,000 sec. ft. to minimums of less than 6000 sec. ft., sustained for months at a time.

It is this feature more than any other which has prevented the construction of a power plant in this reach of the river earlier, since the project has been studied for about 40 years almost continuously by various competent organizations. High-capacity initial installation was imperative on account of the size of the dam. This precluded independent operation and the building up of local load, and involved transmission to existing load centers, together with the provision of expensive, relay, steam-generating capacity for use in the low-flow periods.

That the project now has become economically justified is because The Philadelphia Electric Co. System's load is sufficiently large to absorb nearly the entire output of the plant at all times; while operation in connection with the existing steam stations in Philadelphia (utilizing Conowingo Station on the base of the load in high flows and on the peak in low), makes relay steam capacity unnecessary.

Conowingo Dam

Construction was begun in March 1926, and since that time, weather and river-flow conditions have been so favorable that the original schedule for completion has been materially bettered. At present, the dam is completed and the pool is full. It is expected that the first two units will be in regular operation early this year.

A lake has been formed extending approximately 14 mi. upstream to the tail-race of the Holtwood Plant of the Pennsylvania Water & Power Co. At normal and maximum elevation of 108.5 ft. above sea level, the area of the pond will be about 8600 acres. With a 7 ft. draw-down, storage is available to the amount of 2,500,000,000 cu. ft., which will be utilized in dry periods to supplement the river flow.

Since the former location of the Columbia and Port Deposit Branch of the Pennsylvania Railroad along the east bank of the Susquehanna River was to be submerged, it was necessary to provide a new road bed above the 108.5 ft. pond level from just below Holtwood to the dam, and below the dam, dropping down at a maximum grade of 0.35 per cent to the original level at Port Deposit—about 16 mi. in all.

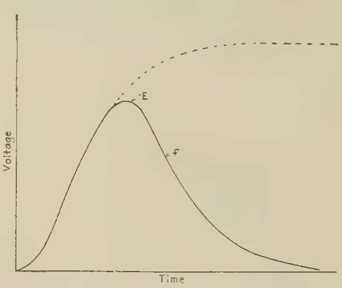

Fig. 3—General Shape of Wave Impressed on Sphere-Gaps

The dam is a gravity-section, concrete structure and is shown in plan and cross-section in Figs. 3 and 4, respectively. Concrete piers on 45-ft. centers serve to carry the crest gates, the gate-crane bridge, and a highway bridge, by means of which the Philadelphia-Baltimore Pike crosses the river.

With all gates open and all wheels at full draft, about

1. Vice-President and Chief Engineer, The Philadelphia Electric Company.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Feb. 13-17, 1928. Complete copies upon request.

880,000 sec. ft. will be discharged without raising the pool level above the normal of 108.5 ft. In comparison, the greatest flood recorded (In June 1889, coincident with the Johnstown Flood) was 750,000 sec. ft.

Conowingo Power Station

Fig. 5 is a cross-section of the power station. Seven generating units are initially installed, (ultimately eleven), each consisting of a turbine of 54,000 hp. at full gate and 89 ft. net head, 81.8 rev. per min., direct-

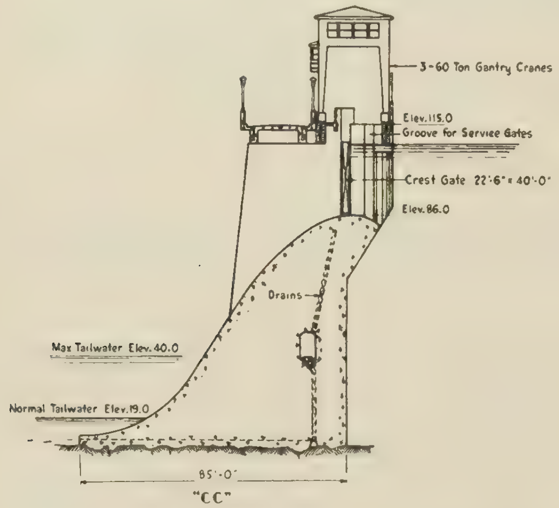

Fig. 4—Cross-Section of Main Spillway Section Conowingo Dam

connected to a 36,000-kw., 40,000-kv-a., 13,800-volt, three-phase, 60-cycle generator; also to a 715-kv-a., 70 per cent power-factor auxiliary alternator for supply-

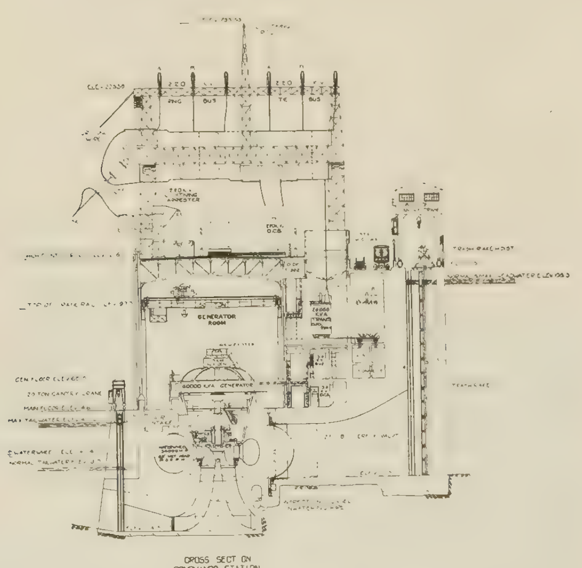

Fig. 5—Conowingo Power Station Cross-Section

ing the more essential auxiliaries; namely the ventilating fan, governor pump and unit exciter.

The generators, coupled in pairs, feed four 80,000-kv-a., 13.8/220-kv., transformer banks, placed in open-top compartments immediately above the 13.8-kv., switch structures. One extra 26,667-kv-a. transformer is provided as a spare for the four banks, The output of the step-up transformers is controlled by the 220-kv. switching station on the roof of the power plant.

Fig. 8 is a late view of the dam and power station from the west bank down stream.

220-Kv. Lines

The 220-kv. transmission lines from Conowingo Power Station to Plymouth Meeting Substation, (approximately 65 mi. long), are carried on steel towers with a normal span length of approximately 1100 ft. The right-of-way width is 315 ft. which provides for three single-circuit tower lines, spaced 85 ft. apart. Initially the two outer tower lines have been built, resulting in a present spacing of 170 ft. between lines. The three conductors of each line are 795,000-cir. mils aluminum, steel-reinforced, and are arranged horizontally, with a spacing of 25½ ft. Each tower line also carries two 183,000-cir. mils aluminum, steel-reinforced ground wires. The insulators are of a high-

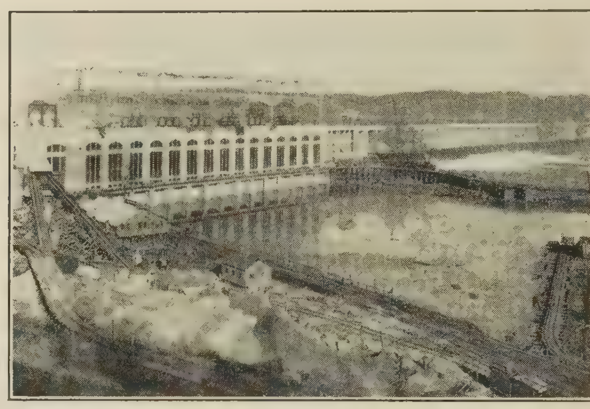

Fig. 8—Conowingo Dam and Power Station, from West Bank—Downstream Side

strength type with 14 units in suspension strings and 16 units in strings in strain position.

Interconnection—General

The interconnection between The Philadelphia Electric Co., the Pennsylvania Power & Light Co. and the Public Service Electric & Gas Co., the first step of which is now practically ready for operation, belongs to the trunk line class of interconnection as it is intended to facilitate the transfer of large blocks of energy. It is the purpose of the three companies by this interconnection so to coordinate their construction and operation programs as to make it result in a maximum saving of investment and operating expense. Load diversity, reserve diversity, and the staggering of construction among the companies are the principal points of saving, and, in addition, the furnishing of emergency power is an important item, although not contributing directly to the saving. The studies made preliminary to the final agreement indicate that the present contemplated construction,—namely, a complete 220-kv. ring between

the systems with suitable facilities for connecting each system to the ring,—when carefully operated, will utilize the best advantage all of the diversity occurring between the system loads for the coming 10 years.

In the interconnection plan, each company designs and constructs the lines lying within its own operating territory, although all three have agreed upon the climatic loading conditions and the general basis of design.

Fig. 11 shows a diagrammatic map of this interconnection. The actual distances (line mileage) are:

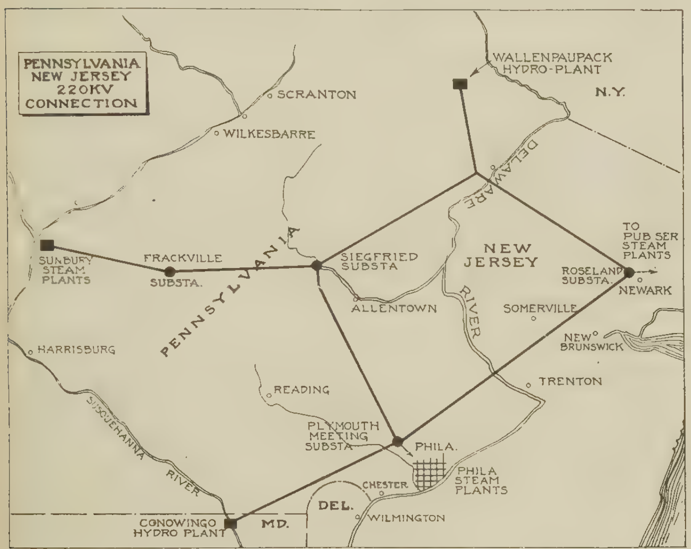

FIG. 11—DIAGRAMMATIC MAP OF PENNSYLVANIA-NEW JERSEY INTERCONNECTION

Plymount Meeting to Siegfried, 49 mi.; Siegfried to Roseland, 82 mi.; Roseland to Plymount Meeting, 77 mi. A portion of the existing line from the Wallenpaupack Hydroelectric Station of the Pennsylvania Power & L ght Co. will be utilized as a portion of the Siegfried-Roseland line when this is built. The interconnection headquarters for general administration and load dispatching is to be established at Siegfried.

The line now practically completed is that from Plymouth Meeting to Siegfried. It is of the same general type of construction as the Conowingo Line, although a number of details relating to foundation, tower design, and insulators were not identical.

CONNECTIONS FROM 220-KV. LINES TO THE PHILADELPHIA ELECTRIC CO. SYSTEM

Plymouth Meeting Substation, the junction point for the 220-kv. Conowingo and interconnection lines and the 66-kv. lines to Philadelphia, was laid out on a tract of about 40 acres. The Conowingo and Interconnection lines terminate at the 220-kv. buses, to which are connected also the 220/69-kv.transformers tying in with the 66-kv. lines to Westmoreland Substation in Philadelphia.

As the single-line diagram indicates (Fig. 14), two 220-kv. buses are installed, provision being made for an ultimate of five 220-kv. lines and six transformer banks, with each bus sectionalized by an oil-circuit breaker. Any bank or line may be connected to either 220-kv. bus, through breakers. The initial installation consists of three lines, two from Conowingo and one from the Siegfried Substation of the Pennsylvania Power and Light Co., and two transformer banks, together with a portion of both buses. On the 66-kv. side of the substation, two buses will be installed with provision for an ultimate of twelve 66-kv. lines, together with the six transformer banks. The initial installation consists of two lines to Philadelphia, and two to the Philadelphia Suburban Counties Gas and Electric Co., and parts of both buses.

A condenser building and a control room are located between the 220-kv. and 66-kv. sections of the station. Initially, three condensers are being installed, with provision for an ultimate of six units.

The transformer banks are self-cooled with a nominal rating of 100,000 kv-a. each; however, with the air-jet radiator cooling to be installed, their capacity will be increased to approximately 130,000 kv-a. These transformers are of the three-winding type, with the 220-kv. and 66-kv. windings connected star and solidly grounded. The delta tertiary winding is rated at 13,300 volts. Ratio changing under load equipment, giving a voltage range of 15 per cent, is provided with these transformers.

The synchronous condensers which are connected to the transformer tertiary windings are each rated at

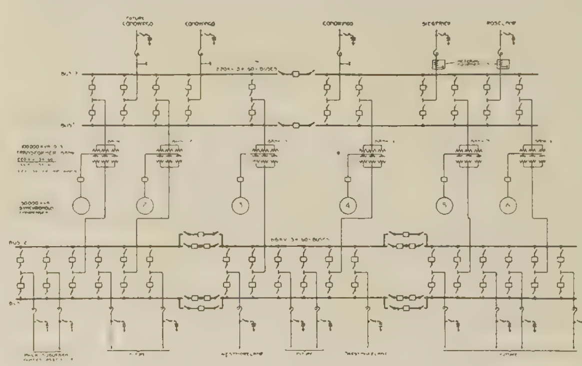

FIG. 14—SINGLE-LINE DIAGRAM OF PLYMOUTH MEETING SUBSTATION

30,000 kv-a. and are equipped with extra high-speed excitation.

Relay protection on the 220-kv. lines consists essentially of special type C Z relays and directional, ground-current relays. Transformer banks and condensers have the usual differential protection. The 66-kv. lines are also protected by C Z and ground-current relays.

The 220-kv. oil-circuit breakers have an interrupting capacity rating of 2,500,000 kv-a., and the 66-kv. line breakers a rating of 2,000,000 kv-a.

66-Kv. Lines

The transmission lines for connection from the 220-kv. system to the existing 66-kv. Philadelphia Electric Co. transmission system are carried from the Plymouth Meeting Substation approximately 10 miles to Westmoreland Substation in northern Philadelphia, generally following along the banks of the Schuylkill River. For approximately one-half of this distance the conventional two-circuit tower construction is used, with an average span length of 800 ft. On account of the limited space available for the remainder of the distance, a special type of four-circuit towers has been utilized; and some of these bridge the railroad right-of-way of the Reading Co. On this portion of the line, a normal tower spacing of 600 ft. has been adopted, and the towers located with a view to the requirements of future electrification catenary structure. Two circuits, each of 500,000-cir. mils copper, have been constructed initially, with provision for an ultimate of six. Two ground wires are installed for each of the two circuit towers.

Westmoreland Substation

The general scheme of connections at Westmoreland Substation and the physical arrangement of equipment are similar to those of the 66-kv. portion of Plymouth Meeting Substation and other Philadelphia Electric Co. 66-kv. substations, two 66-kv. buses being provided to which any line or transformer bank may be connected through oil-circuit breakers. At Westmoreland Substation provision is made for an ultimate of twenty-three 66-kv. sections, five or six of which will be utilized by 66/13.2-kv. transformer banks, and the remainder by transmission lines to Plymouth Meeting Substation and to other 66-kv. substations of the Philadelphia Electric System. Bus sectionalizing, including reactors if their use is found necessary, is provided for at two points in each bus.

The initial installation is two overhead lines to Plymouth Meeting Substation, two underground lines to Richmond Substation, two underground lines to Schuylkill Substation, (together with portions of both buses), and two 66-kv. feeders to two 18,750-kv-a., 66/13.2-kv. transformer banks in a nearby substation. By late summer, two 66/13.2-kv. transformer banks and two synchronous condensers will be installed in the 13.2-kv. section of the station. Ultimately, three and possibly four, transformer banks and three condensers will be installed.

The two banks to be installed will be rated at 60,000 kv-a. each with possible provision for increasing this rating by air-jet radiator cooling. The banks will also be provided with ratio changing under load equipment giving a 10 per cent voltage range.

The synchronous condensers will be rated at 30,000 kv-a. each, and will be equipped with high-speed excitation.

Relay protection on the 66-kv. lines consists of *C Z* duplex relays for protection against both line-to-line and line-to-ground faults. Transformer banks and condensers will have the usual differential protection.

The 66-kv. oil-circuit breakers have an interrupting capacity rating of 2,000,000 kv-a.

Relation Between the Conowingo Project and the Interconnection

The Conowingo and Interconnection Projects have many favorable reactions upon each other. One of these is the common use of facilities for connecting the 220-kv. lines with The Philadelphia Electric Co.'s existing transmission system. The cost of Plymouth Meeting Substation and of Westmoreland Substation, for either the Conowingo project or the interconnection separately, would have been considerably greater than the proportionate share of the actual combined construction cost.

While two 66-kv. lines from Plymouth Meeting Substation to Westmoreland Substation would have been required for the Conowingo Project alone, and one for the initial interconnection step alone, because of the short period of simultaneous maximum demand, two lines only are being installed for both the first year.

The output of the Conowingo Project can be completely absorbed earlier with the interconnection, since the minimum combined load of the three systems is well above the full-load capacity of Conowingo Station. Likewise, Conowingo's value in replacement of steam generating capacity at all times of the year is greater with the interconnection.

In general, the operation of Conowingo Station will be as a base load plant during the periods of high-water flow and as a peak-load plant when the water flow is low. During the summer, when the flow is low and the load curves of all the interconnected system are fairly flat, it will be used as a reserve plant owing to the short time required for starting up a hydro generating unit.

It is hoped that this brief presentation of the largest interconnection yet attempted, embracing three of the leading power supply companies of the United States, and including Conowingo Station, (in its ultimate capacity the largest, single hydroelectric station), may be of value to all those interested in the general subject, and especially to those who find themselves faced by similar problems.

The author desires to express his thanks to Messrs. F. C. Ralston, R. A. Hentz and P. H. Chase of The Philadelphia Electric Co., for their helpful assistance in collecting and compiling the material contained in this paper.

Abridgment of

Compressed Powdered Permalloy

Manufacture and Magnetic Properties

BY W. J. SHACKELTON[1] and I. G. BARBER[2]

Associate, A. I. E. E. Non-member

Synopsis.—The paper gives a brief description of the manufacture of magnetic cores of compressed permalloy powder followed by information covering their magnetic properties with particular reference to their use in loading coils. Production of the powder, and its insulation, pressing and annealing, are discussed. Under magnetic properties, permeability, core loss, and modulation are treated. Curves are given illustrating the characteristics of interest in connection with the design and application of loading coils; and comparisons to corresponding characteristics of compressed powdered iron are made throughout.

THE method of manufacture and the properties of compressed powdered iron cores were described by Buckner Speed and G. W. Elmen[3] in a paper presented before the Institute in 1921.

Some years ago, a nickel-iron alloy, particularly valuable for its magnetic properties, was developed.[4] This alloy, known as permalloy, was described by Arnold and Elmen[5] in 1923. Because its permeability at low fields is many times higher than for any other known magnetic material, permalloy is specially adapted to many uses in the realm of communication. Until recently, however, it has been fabricated only in the form of ductile sheets that could be blanked to various shapes for use in such telephone apparatus as relays and transformers, or in the form of wire or tape that could be applied to the continuous loading of submarine telegraph cables.

On account of the low hysteresis loss that is characteristic of permalloy, its application to the cores of loading coils seemed desirable.

Early attention was directed toward the possibility of fabricating permalloy into a powder, and of insulating and forming this powder, under high pressure, into core parts.[6] Many difficult problems have been encountered in this work; and it was only after a large amount of experimental development that the method now in use for commercially attaining this end was evolved. The present paper describes this method and discusses the important, characteristic properties of such compressed powdered permalloy cores.

MANUFACTURE

Manufacture of Permalloy Powder. The first part of the problem, to develop a method for economically manufacturing on a large scale the fine alloy powder, was undertaken and solved by the engineers of the Western Electric Co. This work, due largely to C. P. Beath and H. M. Heinicke, has lead to the establishment of a melting and rolling practise by means of which the permalloy can be made so brittle that strips ¼ in. thick can be easily broken by hand. Such brittle material is easily reducible to a fine powder by means of a hammer mill, a ball mill, or attrition mill. Fig. 1 shows a photomicrograph of a properly rolled slab. The fine crystals and the fracture following the crystal boundaries are to be noted.

Manufacture of Compressed Powdered Permalloy. Cores made from uninsulated permalloy powder have high eddy-current losses, thus making it necessary to insulate the individual particles before pressing. Early attempts at doing this were unsuccessful, partly due to the fact that the particles, hardened by the mechanical working in the ball mill, sheared through the thin film of enveloping insulation during the pressing operation. In order to reduce this shearing action it was found advantageous to soften the powder by annealing it before insulating. This annealing also has a desirable effect upon the hysteresis loss. During the annealing operation, the powder sinters together into a hard cake. This cake, however, is easily reducible to powder again by passing it through a rotary crusher and an attrition mill. The resulting annealed powder is of a silvery white color and contains a wide variety of sizes of particles.

FIG. 1—PORCELAIN INSULATORS TESTED

The next part of the problem encountered,—that of insulating the permalloy powder,—was decidedly more complex than for compressed, powdered iron cores, as

1. Bell Telephone Laboratories, Inc.
2. Western Electric Company, Inc.
3. *Magnetic Properties of Compressed Powdered Iron*, Buckner Speed and G. W. Elmen, TRANS. A. I. E. E., Vol. 40, 1921, p. 596.
4. U. S. Patent 1586884, June 1, 1926, G. W. Elmen.
5. "Permalloy, An Alloy of Remarkable Magnetic Properties," H. D. Arnold and G. W. Elmen, *Jl. of the Franklin Institute*, Vol. 195, No. 5, 1923.
6. U. S. Patent 1523109, Jan. 13, 1925, G. W. Elmen.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., February 13-17, 1928. Complete copies upon request.

insulated powdered permalloy cores must withstand a heat treating operation in order to develop their characteristic properties.

The method employed makes use of several refractory materials, some of which are mixed dry with the permalloy powder, and then others added in a water solution. The amount of insulating material added is regulated so as to control within limits the permeability of the pressed cores.

The insulated permalloy powder is formed into cores by pressing it in steel dies at approximately 200,000 lb. per sq. in. Fig. 2 shows the effect of forming pressure upon permeability.

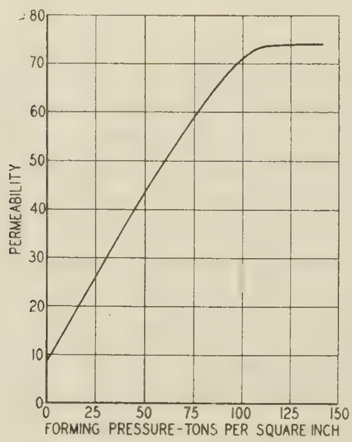

Fig. 2—Effect of Forming Pressure on Permeability of Compressed Powdered Permalloy

PROPERTIES OF COMPRESSED, POWDERED PERMALLOY

Specific Gravity. As noted, the relative proportion of powdered alloy and of insulating material is varied in the control of the volume permeability. Within the limits generally found necessary for this purpose, the specific gravity varies from 7.8 to 8.3.

Tensile Strength. As is the case with powdered iron core rings, the compressed powdered permalloy rings are quite strong enough to satisfy all manufacturing process requirements relative to handling and to machine winding. Tests to rupture on individual rings give an average breaking point strength of 265 lb. per sq. in. in tension.

Resistivity. The resistivity as measured by d-c. methods directly on the rings may vary over a considerable range without having significant effect on the magnetic properties. Typical values are from 1 to 20 ohm-cent. It is found that when the resistivity falls below this range it is an indication of incomplete insulation of the particles, and of higher than normal eddy-current losses.

Permeability. Fig. 3 shows a typical permeability-induction characteristic for both powdered permalloy and for Grade B powdered iron. The significant differences in favor of the new material are (1) its much larger initial value, being over twice the value for the powdered iron (2) the wider range of induction over which it is substantially constant, from 0 to 100 gausses as compared with 0 to 30 gausses, (3) the smaller percentage change over a rather wide range of induction. For example, the maximum change from the initial value up to an induction of 4000 gausses is about 10 per cent as compared to 75 per cent for the powdered iron. The values exhibited by these curves are for typical samples. Differences of initial permeability between individual cores must be allowed for commercial manufacture. For the compressed powdered permalloy, all cores have values between 69 to 81, allowing a maximum variation from the mean of about ± 8 per cent. Considering the varied nature of the processes through which the material for the cores and finally the cores themselves have to pass, in the course of which the permalloy is subjected to severe mechanical working and to large stresses, (and the well-known sensitivity of permalloy in these respects), this tolerance is seen to be extremely close. In comparison, it may be noted that in other magnetic materials as ordinarily manufactured, variations of ± 30 per cent in permeability are very common. In the manufacture of the coils their inductances are still further controlled by adjustment of the windings.

Loading coils are designed so that over the normal range of telephone-current values the induction in the coil cores due to these currents does not exceed the initial nearly horizontal portion of the permeability-induction curve of Fig. 3. Currents of much larger value may, however, result from induction or accidental connection to sources of d-c. or low-frequency power; and it is a requirement that these service hazards shall not seriously alter the coil inductance. In this respect the portion of the curve at inductions above 600 gausses is of interest. An effect of more importance, however, than that shown by this curve is indicated in Fig. 4, which shows typical changes in initial permeability due to the residual effect of previous large inductions, both positive and negative. It will be noted that the

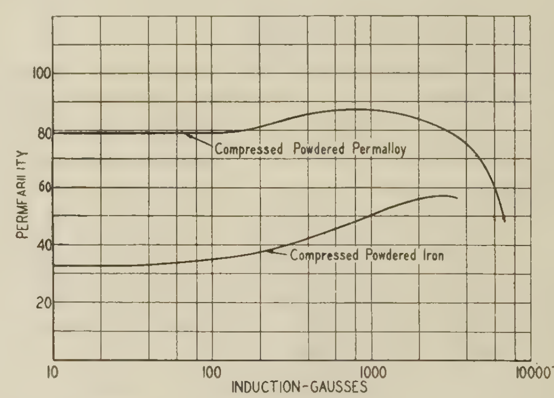

Fig. 3—Permeability-Induction Characteristics of Compressed Powdered Permalloy and Grade B Compressed Powdered Iron

change has a maximum value in the vicinity of an induction of 2500 gausses. The changes, however, are markedly small, the maximum departure from the initial point being less than 0.5 per cent. Having been once heavily magnetized, the material acquires a new mean permeability, about 0.2 per cent higher than it had initially; and departures from this value do not exceed 0.3 per cent normally.

Core Losses. In the application of the material to specific designs it is necessary to know the relation between the core losses, frequency and value of the operating induction, or flux density. For the purpose of studying these relations the equation

$$W = \eta\, v\, f\, B^{x} + \gamma\, v\, f^{2}\, B^{2} \qquad (1)$$

is a useful starting point. However, as the matter of final interest is the equivalent series resistance of the coil, it is convenient to reduce the above equation to the following form:

$$\frac{Rt}{L} = 8\,\pi\,\eta\, f\,\mu\, B^{x-2} + 8\,\pi\,\mu\,\gamma\, f^{2}. \qquad (2)^{7}$$

The symbols in these equations have the following significance:

W = power loss in ergs per sec.
η = hysteresis coefficient.
v = core volume in cm.^{3}
f = frequency in cycles.
B = maximum flux density.
γ = eddy-current coefficient.
Rt = equivalent series resistance due to core loss.
L = inductance of coil in henrys.
γ = permeability.
x = hysteresis exponent.

The first terms of the right-hand members of the two equations give, respectively, the hysteresis loss and the equivalent series resistance caused by it, and the second the eddy-current loss and its equivalent series resistance. Considering the latter it is evident that the effective resistance due to eddy-current losses is independent of the operating induction; that is, a coil of given inductance having a constant permeability core will have the same resistance due to eddy-current loss, regardless of whether it is made small or large. This, expecially for the higher frequencies where the eddy-current losses may predominate, is a serious limitation to the design of high-efficiency coils. The factor $8\,\pi\,\mu\,\gamma$ is a constant for the material that defines its quality from the eddy-current loss standpoint. To insure low eddy-current losses, it is necessary to make this factor relatively small. In the case of the powdered permalloy, this is accomplished not only by reducing the eddy-current coefficient γ by the use of insulated finely ground particles, but also by limiting the working permeability of the compressed core. Table 1-*A* lists averages values of eddy-current coefficients and the product $\mu\,\gamma$ for the powdered permalloy and for grade B powdered iron. The coefficient for the permalloy material is nearly 50 per cent less than that of the powdered iron, in consequence of which the product

TABLE I
MAGNETIC PROPERTIES OF COMPRESSED-POWDER CORES AT LOW INDUCTIONS

A. Permeability and Eddy-Current Coefficient

	Permalloy	Grade B iron
Permeability—μ (mean)	75	35
Eddy-current coefficient—γ	0.0021×10^{-6}	0.0035×10^{-6}
Product—$\mu\,\gamma$	0.16×10^{-6}	0.123×10^{-6}

B. Hysteresis Loss

Induction (B_{max})	Loss, ergs per cm.^{3} per cycle — Permalloy	Iron (see note)
1 Gauss	0.017×10^{-4}	0.064×10^{-4}
2 "	0.08	0.33
5 "	0.64	3.5
0 "	3.7	23.8
15 "	10.7	75.5
20 "	23.5	172
30 "	72	

Note: Hysteresis loss values for the powdered iron are about 8 per cent lower than those given by Speed and Elmen; this reduction being due to a small improvement made in the Grade B material subsequent to the publication of the Speed-Elmen paper.

$\mu\,\gamma$ is only 38 per cent larger—even though the permeability is more than doubled.

Table 1-*B* gives data showing the hysteresis loss in ergs per cu. cm., per cycle, for a typical range of flux densities. These data are plotted in Fig. 5. On

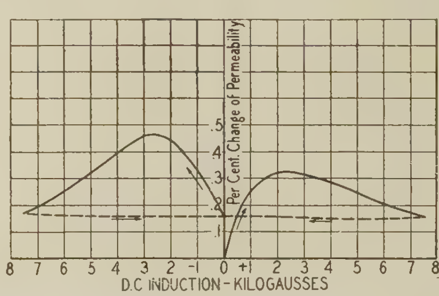

Fig. 4—Residual Effect of D-C. Induction on the Initial Permeability of Compressed Powdered Permalloy

account of the large ratios represented, logarithmic scales are used so as to open up the plot at the lower values. The curves show a slight departure from linearity, indicating that the hysteresis exponent X is not a constant even for the small inductions represented. The curves for the two materials, however, are nearly parallel showing them to have at each point about the same exponent. The outstanding difference is the large displacement between them. For a given hysteresis loss powdered permalloy is capable of operation at much higher densities.

The factor $\eta\,B^{x}$ of the hysteresis term of the loss equation evidently is the loss per cu. cm., per cycle. Hence, dividing the latter by B^2, there is obtained the variable part of the corresponding term of the

7. For the derivation of this equation reference is made to Speed-Elmen, Loc. cit.

equivalent resistance equation, that is ηB^{x-2}. Such values multiplied by the mean permeability are plotted in Fig. 6. The ordinates of these curves multiplied by the factor $8 \pi f$ give the hysteresis loss resistance in ohms per henry for the frequency and flux density desired. Here the outstanding superiority of the powdered permalloy is more clearly evident, the

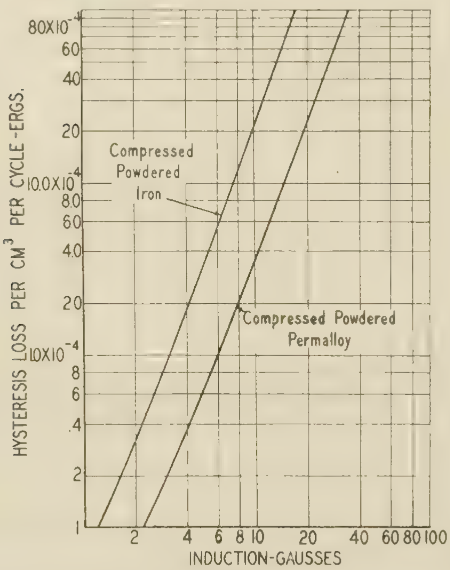

Fig. 5—Hysteresis Loss Characteristics of Compressed Powdered Permalloy and Grade B Compressed Powdered Iron

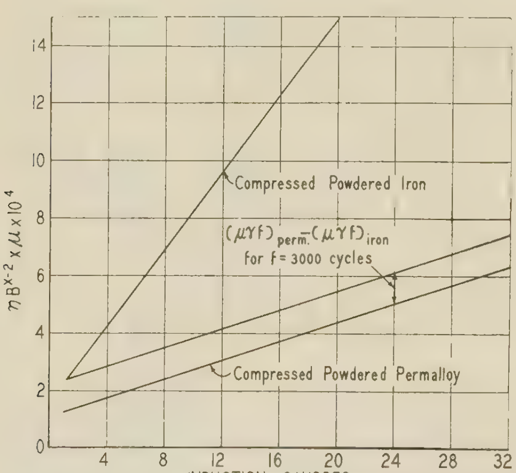

Fig. 6—Relation between A-c. Induction, B_{max}, and Hysteresis Loss Resistance Factor, $\eta B^{x-2} \times \mu$, for Compressed Powdered Permalloy and Compressed Powdered Iron

ratio of resistances due to hysteresis losses mounting very rapidly with increasing density.

These curves show at a glance the densities at which hysteresis loss resistances are equal. Of course, it is often more important to have the total core loss resistances equal at a particular frequency. Since, as previously mentioned, the eddy-current resistances are constant with respect to flux density, it follows that their difference is also constant. Hence, a curve drawn parallel to, and displaced from, the hysteresis loss curve along the loss axis to an amount proportional to this difference gives the densities at which total core-loss resistances are equal. Such a curve is included in Fig. 6 for a frequency of 3000 cycles, this being slightly above the maximum frequency which certain powdered-iron core loading coils were designed to transmit efficiently.

For the initial application of this material to commercial use, an intermediate course is being followed; that is, coils, both lower in cost and better in quality in all of these respects, have been developed. For the two main types of facility required, core volumes have been decreased by 70 per cent in one case and by 85 per cent in the other. Fig. 7 illustrates the larger of these reductions in core and coil sizes. Combined with these reductions in size and consequent savings in cost, there are appreciable improvements in effective resistance and also, in flutter and modulation.

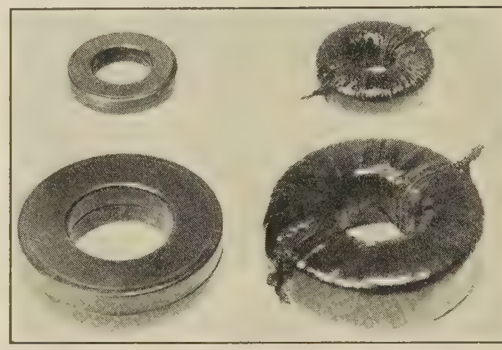

Fig. 7—Right—Compressed, Powdered Permalloy and Compressed, Powdered Iron Core Loading Coils of Equal Efficiencies. Left—Cores Used in these Coils

20,000 MILES OF NEW HIGHWAYS PLANNED FOR 1926

Road construction in 1928 will doubtless exceed previous building records, according to reports received and announcement by the Bureau of Public Roads in the Dept. of Agriculture.

Improvement of the State and Federal-aid highway systems under the supervision of the highway departments of the several states will go forward during the season now opening with the construction of more than 20,000 mi. of surfaced roads, and about 8000 mi. to be graded and drained.

Abridgment of

Surge-Voltage Investigations on the 140-kv. System of the Consumers Power Company During 1927

BY J. G. HEMSTREET*
Associate, A. I. E. E.

and

J. R. EATON*
Associate, A. I. E. E.

Synopsis.—*During the past four years, the Consumers Power Company has been making studies of surge voltages on its 140-kv. system in Michigan. Previous Institute papers have summarized the results of these investigations up to the end of 1926. This paper describes the system, outlines the studies made during the summer of 1927, and presents the results obtained during that season.*

Introduction

In an effort to learn more of the electrical behavior of transmission lines, particularly under transient conditions, the Consumers Power Company and the General Electric Company conducted a cooperative investigation on the Power Company's 140-kv. transmission lines during the summer of 1927. Surge voltage recorders were connected to the lines at various points in order to measure the magnitude and time of occurrence of transient voltages. Data obtained from these instruments were correlated with system operation and disturbances as recorded in the load despatchers log.

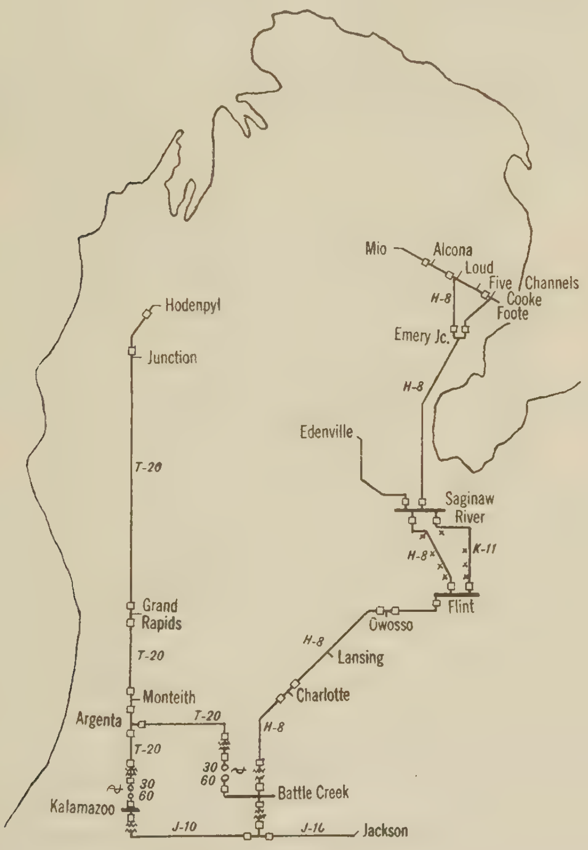

Fig. 1—Consumers Power Co., 140-Kv. Transmission System 1927

□ Oil circuit breakers
X Surge-voltage recorder stations

Description of System

The 140-kv. interconnected system of the Consumers Power Company is shown diagramatically on the map of the State of Michigan, Fig. 1. The system consists of three distinct parts interconnected through frequency changers and transformer banks, and is operated with isolated neutral throughout. Numerous spur lines of lower voltages feed from the various stations on the 140-kv. system.

Transmission Lines on Which Instruments Were Installed

The surge-voltage investigation was conducted on the H-8 and K-11 lines between Saginaw River Steam Plant and Flint. Under normal conditions, these two lines operate in parallel, being tied together at the substation buses. At the beginning of the summer, neither line was equipped with a ground wire, but during the summer, a ground wire was strung in place over the K-11 line. As these two lines are relatively close together, they are subjected to about the same storm conditions.

Surge Voltages Due to Lightning

Number and Magnitude. During the investigation, 76 surge voltages which were attributed to lightning were recorded. The number of these surges, exceeding various times normal values, is shown by the curves of Fig. 8. It will be noted that only 20 per cent of the recorded voltages exceeded five times normal. (570 kv.)

Polarity. Surges voltages attributed to lightning are classified as to polarity in Table III.

These data indicate that all lightning surge voltages of appreciable magnitude on this particular system were oscillatory during the period of the tests. This statement cannot be made as a definite conclusion because of several factors among which are:

1. The possibility of reflections with reversed polarity of voltage.

2. Possibility of secondary oscillatory surges resulting from circuit-breaker operation.

*Both of the Consumers Power Co., Jackson, Mich.

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928. Complete copies upon request.

3. Because of limitations of the instrument, two unidirectional surges of opposite polarity, occurring with little intervening time interval, record as one oscillatory surge voltage.

Nature. Lichtenberg figures of three different natures were recorded by lightning surge voltages:

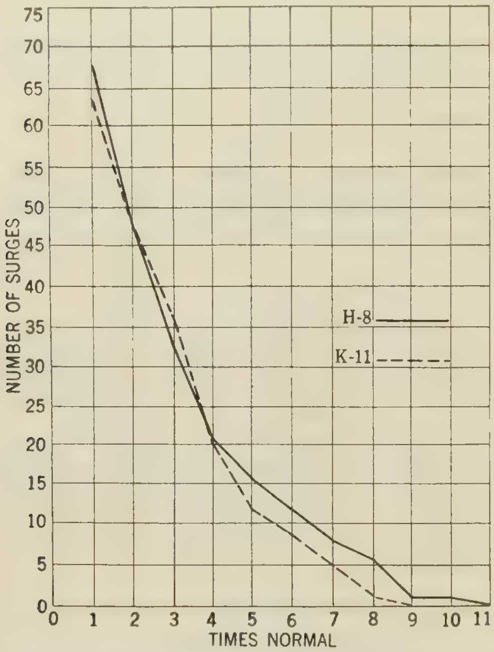

Fig. 8—Number of Lightning Surge Voltages Exceeding Various Times-Normal Values

Entire season
H-8 and K-11 lines

highly damped (H. D.), medium damped (M. D.), and slightly damped (S. D.). The highly damped figures are interpreted as having been produced by surge voltages which were of extremely short duration,

TABLE II
CLASSIFICATION OF SURGE VOLTAGES

Origin	Number	Highest crest value	
		Times normal	Kv.
Lightning	76	10.0 +	1140
Switching	93	3.3	375
Accidental short circuits and grounds	1	3.6	410
Unknown	49	5.7	640
Total	219		

Note: Normal crest voltage to ground = 114 kv.

lasting for only a few polarity reversals. The medium damped figures are produced by surge voltages which are less rapidly damped and may last for an appreciable length of time. Such surge-voltage registrations in almost every case correlated with arc-over from line conductor to ground and with automatic circuit breaker operation. These medium damped figures apparently are peculiar to the isolated neutral system, and are probably produced by line oscillations following flashover. The slightly damped figures are of uncertain origin and seem to be dependent upon the type of potentiometer with which the surge recorder is connected to the line. In view of this uncertainty, conclusions drawn from slightly damped figures are open to question. Continued laboratory studies should lead to an accurate interpretation of the slightly damped figures.

Surge voltages which were recorded by highly

TABLE III
POLARITY OF LIGHTNING SURGE VOLTAGES

Polarity	Number	Highest crest value	
		Time normal	Kv.
Unidirectional			
Positive	1	1.9	216
Negative	3	1.2	137
Oscillatory			
Highest crest value			
Positive	28	8.4	960
Negative	20	7.5	855
Positive and negative crest values equal	24	10.0 +	1140 +

damped or slightly damped figures were very similar as regards magnitude and extent over the transmission system. In almost all cases, such disturbances were

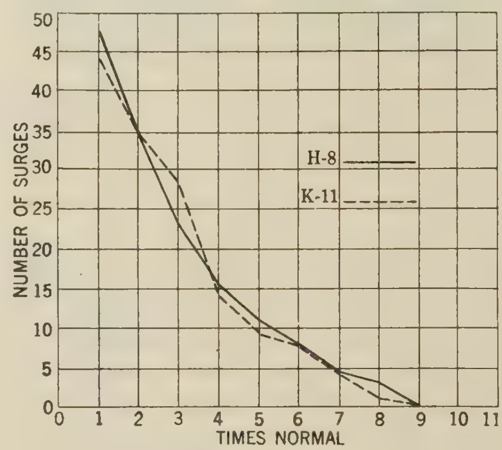

Fig. 9—Number of Lightning Surge Voltages Exceeding Various Times-Normal Values

Before ground wire was installed on K-11 line

confined to less than 20 mi. of line. The magnitude of surge voltages recorded by medium damped figures was slightly less than the magnitude of those producing highly damped or slightly damped figures, but they were quite different in that they recorded with almost equal value at all instrument locations.

Attenuation Along the Line. As pointed out above, surge voltages of medium damped characteristics are recorded with almost equal magnitudes at all recorder stations, and hence show practically no attenuation along the line. Surge voltages recorded by either slightly damped or highly damped figures showed considerable reduction in magnitude from one instrument station to the next. Surge voltages of the highly damped type in some cases reduced from 250 kv. to 0 kv. in 10 mi., or at the average rate of 25 kv. per mile.

Those recorded by slightly damped figures, in some cases reduced from 900 kv. to 300 kv. in 10 miles, or at an average rate of 60 kv. per mile.

Comparison of insulator flashover to surge voltage recorder data showed that in some cases the voltage reduced from a value sufficient to cause insulator flashover (about 1000 kv.) to 500 kv. in distances of 4 to 10 miles. This indicates average reductions in voltage between 50 and 125 kv. per mile.

Protective Value of the Ground Wire. During the investigation, a ground wire was strung in place over the K-11 line, making possible a study of the operation of this line with and without a ground wire, and a comparison of its performance to that of the H-8 line, which has no ground wire. Fig. 9 shows the

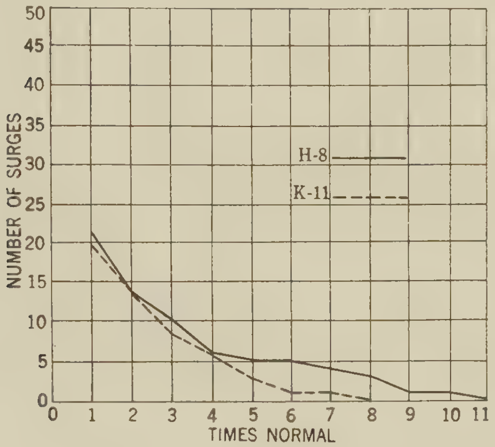

FIG. 10—NUMBER OF LIGHTNING SURGE VOLTAGES EXCEEDING VARIOUS TIMES-NORMAL VALUES

Ground wire on K-11 line

number and magnitude of surge voltages recorded on the H-8 and K-11 lines before the ground wire was completely installed on the K-11. These curves indicate that during that period, the voltages recorded were about equally severe on the two lines. The curves of Fig. 10 show the number and magnitude of the surge voltages recorded after the ground wire was installed. It will be noted that during this period the recorded surge voltages were considerably less severe on the K-11 than on the H-8.

Relation of Conductor Height to Voltage Measured. The curves of Fig. 11 and 12 show the magnitude and number of surge voltages recorded on the top, middle, and low conductors of the H-8 and K-11 lines, respectively, using only the data obtained at those stations where instruments were installed on all three conductors. From these curves, it is seen that no definite relation exists between the magnitude of surge voltages measured and conductor height. It is thought that transpositions in the line, reflection of the transient waves, and other factors, so complicate this study that voltages measured at a few recorder stations do not give a true indication of the relative voltages induced at the origin of the lightning disturbances.

Surges Coincident with Switch Trip-Out. In every case of switch trip-out on the 140-kv. system, surge voltages were recorded at one or more of the surge

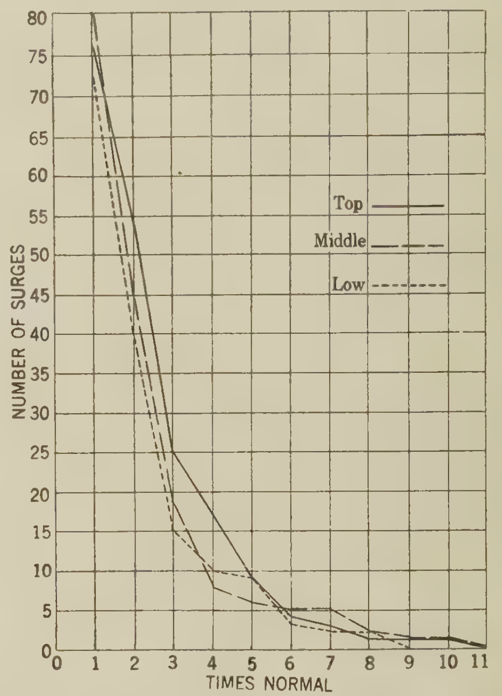

FIG. 11—NUMBER OF LIGHTNING SURGE VOLTAGES EXCEEDING VARIOUS TIMES-NORMAL VALUES, RECORDED ON TOP, MIDDLE, AND LOW CONDUCTORS

H-8 line

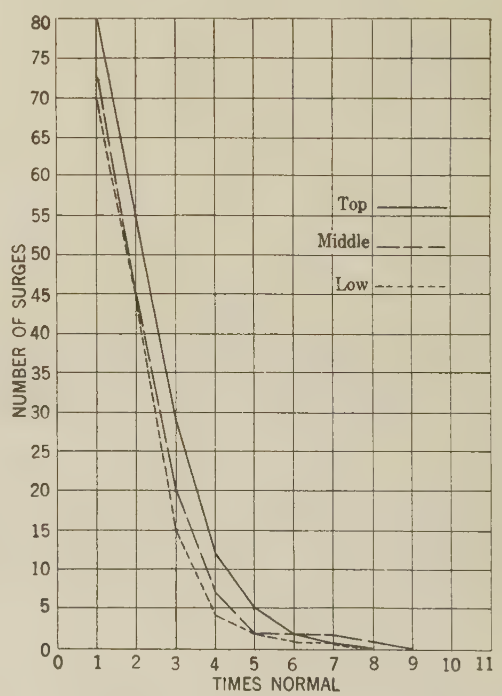

FIG. 12—NUMBER OF LIGHTNING SURGE VOLTAGES EXCEEDING VARIOUS TIMES-NORMAL VALUES, RECORDED ON TOP, MIDDLE, AND LOW CONDUCTORS

K-11 line

recorder stations. Trip-outs of the H-8 or K-11 lines between Saginaw River and Flint produced registrations on practically all instruments in operation. In

some instances, the recorded voltages were low (400 kv.) as compared with the generally accepted value of insulator flashover (approximately 1000 kv.). However, it is reasonably certain that in such cases, the lightning discharge took place at a point on the line some distance from a recorder station, and the voltage wave attenuated considerably before reaching the first instrument. The transient recorded at the various instrument stations was probably the results of the arcing ground or of circuit breaker operation, rather than of the voltage disturbance set up by the lightning itself. The figures recorded at the time of switch trip-outs were predominately of the nature designated as medium damped, although also highly damped and slightly damped figures were frequently recorded.

Surge voltages not coincident with switch trip-outs were for the most part very local in extent, of values from 1 to 10 times normal (114 to 1140 kv.) and of all three figures types with those of highly damped and slightly damped characteristics predominating.

Surge Voltages on the Ground Wire. Table V shows

TABLE V
LIGHTNING SURGE VOLTAGES ON GROUND WIRE

On ground wire		On conductor
At mid-span 318-319 Kv.	At tower 318 Kv.	At tower 318 Kv.
+35 +	+28	+206 −160
+24 −16	0	−456 +285
− 6 + 4	0	−410 +285
+5.5	0	Record obscured
−3.7	0	−850 +182
+2.0	0	+205 −160

the lightning surge voltages recorded on the ground wire at mid-span and at the tower, and the highest value recorded on either of the line conductors at the same tower.

The data show that a much higher value of voltage may appear on the ground wire at mid-span than at the tower, possibly due to the finite length of time required for the transient to travel along the wire to ground at the tower.

Surge Voltages Due to Switching Operations

Surge voltages recorded coincident with routine switching operations were 92 in number, were of highly damped figure characteristics, and reached a maximum value of 3.6 times normal (410 kv.). Switching on the two lines between Saginaw River and Flint invariably produced disturbance which recorded on the instruments, but switching on other parts of the 140-kv. system sometimes failed to produce registrations. Switching on equipment connected to the H-8 and K-11 lines through transformers produced no record on the instruments. Deenergizing of either the H-8 and K-11 lines resulted in voltage surges of higher magnitude than were produced by energizing the same line.

Summary of Results

On the 140-kv. lines of the Consumers Power Company between Saginaw River and Flint in 1927:

1. Lightning produced voltage surges whose magnitudes were as high as 1100 kv.

2. During this particular investigation, all surge voltages of appreciable magnitude due to lightning recorded on the two-electrode instrument as oscillatory, with no preponderance of positive or negative polarity indicated. In a number of cases, the record of the surge from the lightning itself was undoubtedly considerably obscured by secondary oscillations from arcing grounds and circuit breaker operation.

3. The surge voltages due to lightning were characterized by three different figure types; highly damped, medium damped, and slightly damped.

4. Surge voltages characterized by medium damped figures showed very little change in value from station to station, and frequently correlated with arcing grounds and switch trip-outs.

5. Comparison of simultaneous registrations of highly damped and slightly damped surge voltages showed the reduction in voltage from station to station to be of the order of 50-kv. per mi. From insulator flashover, the attenuation appeared to be in the order of 100 kv. per mile.

6. The data indicated that the ground wire afforded some protection against lightning disturbances.

7. No definite relation was shown between conductor height and voltage recorded.

8. Surge voltages recorded coincident with switch trip-outs due to lightning frequently were of a magnitude less than 400 kv. though higher voltages undoubtedly existed on the line at points remote from recorder stations.

9. Lightning surges which produced no switch trip-outs were, as a rule, very limited in their extent although they were frequently of a very high value. (800-1100 kv.).

10. Under lightning conditions, voltages in excess of 35 kv. were built up between ground wire and ground at mid-span, without excessively high voltage on the line conductors. The voltage from ground wire to ground was always considerably less at the tower than at mid-span.

11. Normal switching operations produced surge voltages of low value which extended over considerable length of line.

12. Numerous surge voltages were recorded which could not be correlated with lightning storms or system switching. The magnitudes of such disturbances were relatively low, reaching values no higher than 5.7 times normal (650 kv.).

Abridgment of

The Drive of Tandem Rolling Mills

BY A. F. KENYON*

Associate, A. I. E. E.

Synopsis.—The paper briefly discusses the development of the tandem type of rolling mill, and the requirements of electrical drives for such mills; and presents methods of calculation of power requirements.

CHANGING conditions in the steel rolling mills of this country have caused the development and widespread application of what are quite commonly termed "tandem" rolling mills. The tandem type of mill has the advantages of great flexibility, high tonnage output, low labor costs, compactness of layout, and uniform quality of product. This type has been applied successfully to the production of thin flat stock up to 50 in. wide, rod, bar, merchant and structural shapes. In this type of mill, the several finishing stands are closely spaced in a continuous line and are individually driven by separate motors. The length of the billets and the spacing between stands are such that a single piece of steel may be in several stands at one time, and for periods of several seconds. It is therefore essential to the successful operation of such a tandem mill that the speeds of the several driving motors be susceptible of easy and accurate adjustment, in order that the stretching, or looping, of the steel between stands may be kept within limits.

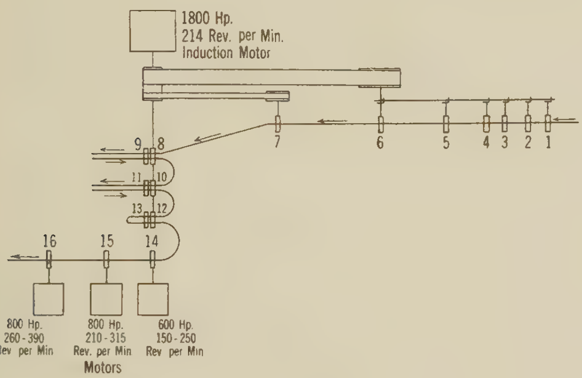

FIG. 1—14-IN. STRIP MILL AT CUYAHOGA WORKS OF AMERICAN STEEL AND WIRE COMPANY

Illustrating first application of d-c. adjustable-speed motors to tandem finishing stands Installed 1908-9

DEVELOPMENT OF TANDEM OPERATION

During 1908—1909 the American Steel and Wire Company installed a 14-in. mill which is of considerable interest, in that it was the first application of separate d-c., adjustable-speed motors for the individual drive of the three tandem finishing stands. The arrangement of the stands is shown by Fig. 1. At the top speed of 390 rev. per min. on stand 16 motor, the delivery speed is approximately 1325 ft. per min. The mill has a range of capacity from 18-gage strip up to about 4 in. wide to 14 gage material up to about 10 in. wide. In its arrangement of the finishing stands, the mill varies but little from more recent designs.

With the more recent installations, the trend has been toward the elimination of stands in train, with

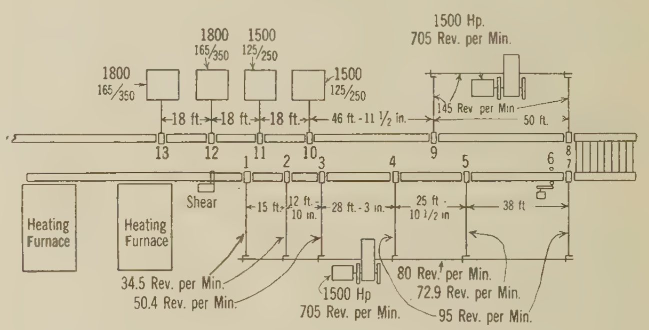

FIG. 2—20-IN.—16-IN. SEMI-CONTINUOUS STRIP MILL AT WEST LEECHBURG STEEL COMPANY

The four finishing stands are individually driven by two 1500-hp. and two 1800-hp. d-c. motors

final development of the present mills in which the stands are arranged in one continuous line. As an intermediate step in the development, Fig. 2 is included to show the layout of the semi-continuous mill of the West Leechburg Steel Company. The equipment and operation of this mill were described in a paper by Jones and Wilson before the April 1924 A. I. E. E. Spring Convention at Birmingham.

The Acme Steel Company has a mill in which the stands are arranged in a single line, eliminating the broadside transfer. The two intermediate stands are close together and are driven by adjustable-speed d-c. motors. This arrangement permits of additional flexibility and permits the rolling of finished strips up to 600 ft. or longer.

Latest designs show a tendency to apply individual motor drives to the roughing as well as the intermediate and finishing stands. A mill for the production of strip up to 50 in. wide, construction of which will soon be completed, consists of 11 roll stands, the first four driven by wound-rotor induction motors, and the last

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*General Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

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seven driven by d-c. motors. The total capacity of the 11 motors is 21,800 hp.

On the tandem stands of the mills so far discussed, d-c. adjustable-speed motors have been applied. The question may logically be asked: Why not use some type of a-c. adjustable-speed drive? To answer this question we should consider first the suitability of such machines for tandem mill operation, and second, the relative cost as compared with other drives.

It is a requirement of any continuous mill in which steel is in two or more stands simultaneously, that the product of delivery speed and cross-sectional area of steel after the pass must be the same for each pass; otherwise the steel will be stretched, or a loop formed between stands. Speed adjustments must therefore accompany any changes in the drafts made in the various passes. Mill operators, in purchasing tandem mill drive equipment, have commonly specified that the motors should have a speed regulation of not more than 2 per cent. Analysis shows, however, that the actual speeds while steel is in the mill, rather than the difference between the friction and rolling load speeds, determine the amount of looping or stretching which will take place. Regardless of the friction-load speeds, each motor will quickly assume its loaded speed as soon as the steel enters the rolls; and if the loaded speeds of each of the several stands are in the correct relation for the reductions being made, there will be no stretching or looping. From this standpoint successful operation can, and is, being obtained with motors having as much as from 8 to 10 per cent of speed regultion on the finishing stands. However, with motors of flatter speed characteristics, speed changes, due to load variations caused by changes in draft, temperature of steel, etc., are kept at a minimum. This makes a comparatively flat speed characteristic in the motors very desirable. Most operators therefore insist on motors of flat speed characteristics.

There is a type of mill, such as the 10-in. strip mill of the Laclede Steel Company, Alton, Illinois, (Fig. 4) where motors of good speed regulation are quite necessary. In this mill, the six roughing stands are driven by a 1500-hp. motor, and the four finishing stands, by individual motors of 600-hp. and 720-hp. capacity. The billets are of such length that one piece may be in all stands of the mill simultaneously.

For illustration, assume that the speed regulation of the 1500-hp. motor is 5 per cent and that the speed-load curve is a straight line. Further assume that the friction load is 100-hp. and that the rolling load of each stand is 300-hp. making a total load of 1900 hp. when metal is in all stands. In order to avoid stretching of the steel between stands 6 and 7, it is necessary to have the delivery speed of stand 6 equal to, or greater than the take-up speed of stand 7. That is, the speed of the 1500-hp. motor when carrying a 1900-hp. load must give a delivery speed to stand 6 at least equal to the take-up speed of stand 7. But as the end of the strip leaves stands 1, 2, 3, 4, and 5 in succession, the load on the 1500-hp. motor is reduced, the speed increases, and a loop is formed. Table I shows the data for a particular rolling schedule, and indicates that nearly 5 ft. more material will be delivered from stand 6 than is taken up by stand 7, during the interval between the time when the tail end of a piece leaves stand 1

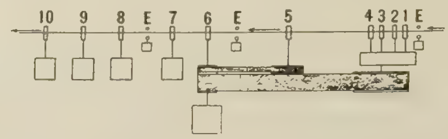

Fig. 4—10-In. Strip Mill of Laclede Steel Company Illustrating the Use of a Multi-Stand Roughing Mill in Tandem with Individual Motor Driven Finishing Stands

Pass	Diam.	Rev. per min.	Motor h.p.
Edger	. .	275/825	100
1	12	31/63	. .
2	12	45/90	. .
3	12	61/122	. .
4	12	90/181	. .
5	11	123/249	. .
Edger	. .	400/1600	35
6	10	198/400	1500
7	10	185/470	600
Edger	. .	400/1600	35
8	10	270/635	600
9	10	395/825	720
10	10	480/1000	720

and the time it leaves stand 6. Remember, too, that this is on the basis that the delivery speed of stand 6, when steel is in all the roughing stands, is exactly equal to the take-up speed of stand 7, and that there is no loop formed until the tail end of the piece leaves stand 1. If, the normal delivery speed of stand 6 with the roughing mill full is slightly in excess of the take-up speed of stand 7, there will be an initial loop between stands 6 and 7 before the steel leaves stand 1. Then by the time the steel leaves stand 6, the loop may have become so large as to be unmanageable. When this motor was first installed, the speed regulation was of the order of 7-8 per cent, due to a misadjustment. Considerable trouble was experienced due to the excessive looping of steel, until adjustments were made to reduce the speed regulation to below 2 per cent.

If we analyze the case of a mill consisting of two or more multi-stand sections, each driven by a motor of poor speed regulation, the loop formed between sections may be much longer than in the case just considered. Referring to Fig. 6, stands 1, 2, 3, and 4 are driven by one motor, while stands 5, 6, 7, and 8 are driven by a second motor. Assume, again, that billets are of such length that one piece may be in all stands simultaneously. Now in order to avoid stretching of the steel, it is necessary that the delivery speed of stand 4, with steel in stands 1, 2, 3, and 4, be equal to, or greater than, the take-up speed of stand 5, when steel is in only stand 5 of the second section. But, as the steel enters stands 6, 7, and 8, the speed of the second motor is

TABLE I

SHOWING LOOP FORMED BETWEEN STANDS 6 AND 7 OF MILL SHOWN IN FIGURE 4, WHEN 1500-HP. ROUGHING MILL MOTOR HAS SPEED REGULATION OF 5 PER CENT. CALCULATION BASED ON ASSUMPTION THAT DELIVERY SPEED OF STAND 6 WITH STEEL IN ALL ROUGHING STANDS IS EQUAL TO TAKE-UP SPEED OF STAND 7

1. Pass number	1	2	3	4	5	6	
2. Roll diameter, in.	12	12	12	12	11	10	
3. Roll rev. per min. at friction load	42	60	81	120	165	265	
4. Cross section of steel after pass, sq. in. 7.50	4.45	3.13	2.32	1.57	1.24	.85	
5. Distance to next stand, in.	40.25	44.50	40.25	345.00	304.50	130.00	
6. Volume of steel to next stand, cu. in.	179	139	93	541	378	110	
7. Motor load with preceding stands empty, hp.	1900	1600	1300	1000	700	400	100
8. Delivery speed of stand 6 with preceding stands empty, in. per sec.	130.2	131.6	133.0	134.4	135.8	137.2	138.6
9. Volume delivered from stand 6 with preceding stands empty, cu. in. per sec.	110.7	111.9	113.1	114.3	115.5	116.7	117.9
10. Interval from time piece leaves preceding stand until it leaves this stand, sec.		1.60	1.23	.81	4.69	3.25	
11. Rate of overfeed from stand 6 during interval (10), in. per sec.		1.4	2.8	4.2	5.6	7.0	
12. Amount of overfeed, in.		2.24	3.44	3.40	26.20	22.75	
13. Total accumulated excess strip between stands 6 and 7, in.		2.24	5.68	9.08	35.28	58.03	
14. Take-up speed of stand 7, in. per sec.	110.7	110.7	110.7	110.7	110.7	110.7	

reduced, and the take-up speed of stand 5 is lower than the delivery speed of the preceding stand. A loop is thus formed. Also as the tail end of the piece leaves stands 1, 2, and 3, the speed of the first motor increases, and the delivery speed of stand 4 exceeds the take-up speed of stand 5 by a still greater amount, so that the rate of loop growth is accelerated.

It is to be noted that in the case of the mill shown in

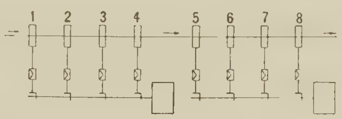

FIG. 6—EXAMPLE OF MILL CONSISTING OF TWO MULTI-STAND SECTIONS IN TANDEM, TO ILLUSTRATE LOOPING OF STEEL BETWEEN SECTIONS CAUSED BY SPEED REGULATION OF DRIVING MOTORS

Fig. 4, the total length of excess material is independent of the length of billets being rolled, and depends only on the speed regulation of the motor and on the layout of the mill. However, in the case of the mill shown in Fig. 6, there is a continuous overfeed as soon as the steel enters the second section of the mill. The loop steadily increases and the total length of excess material is proportional to the length of billets being rolled.

From the foregoing, it is seen that the speed regulation of motors on individual stands need not be excessively close. On motors driving several stands, good speed regulation is of relatively more importance. However, such drives are usually applied on the roughing stands where the length of piece is comparatively short and rolling speeds low so that loops are more easily taken care of. On most mills, the authors believes that motors with as much as 4 or 5 per cent speed regulation will operate successfully, although certain types of mills may require motors of 2 per cent or less regulation.

D-c. motors are ideally suited to the drive of such tandem mills. Speed ranges of 2:1 or greater can be secured by shunt field adjustment. The number of speed points is limited only by the design of the field rheostats, and by the use of coarse and fine adjustment rheostats, each having 100 or 120 points, the total number of settings may be 1000 or more. The inherent speed regulation of shunt or lightly compounded motors can usually be kept within 3 or 4 per cent, over a speed range of 2:1, and by the addition of simple auxiliary equipment the regulation can be maintained as low as 1 per cent.

The speed curve of a shunt wound machine is usually slightly rising with load, so that a light series field is necessary to produce a flat or slightly drooping characteristic. The amount of series excitation required at full field speed with maximum shunt field excitation is different from that required with weakened shunt field. Therefore, to maintain good speed regulation over the entire speed range, it is necessary to vary the series excitation. On some machines this was accomplished by means of series field shunts and one or more switches to cut the shunts in or out of circuit.

More recently, the series excitation is furnished by a "series exciter," which is excited by the motor armature current, thus giving the same effect as a series winding on the motor itself. A rheostat in this excitation circuit is mechanically coupled to the main shunt field rheostat. Both rheostats are thus operated together and resistance values are so proportioned that the proper compounding is secured for each speed setting. Table II shows the almost negligible speed changes from no-load to double load of a 2500-hp. 160/320-rev. per min., 600-volt motor. The first such indirectly compounded equipment was placed in service in November 1926, and there are now installed or building 46 motors totaling over 60,000 hp., to be used on eleven different mills.

A-c. adjustable speed motors may be made to have a speed regulation sufficiently low for the successful operation of some tandem mills, and there are a number of mills so driven. However, most tandem mills require several drives, and if d-c. motors are used,

power can be supplied from a few large motor generator sets or rotary converters, while with a-c. drives, a separate regulating machine is required for each motor.

TABLE II

SPEED REGULATION OF 2500 HP., 160/320 REV. PER. MIN., 600-VOLT, 3360-AMPERE, INDIRECTLY COMPOUNDED, D-C. MOTOR

1	2	3	4
Armature amperes	Bus volts	Shunt field amperes	R. P. M.
100	600	35.8	160
3360	600	35.8	160
6720	600	35.8	159
120	600	19.2	210
3360	600	19.2	210
6720	600	19.2	210
140	600	14.0	265
3360	600	14.0	265
6720	600	14.0	264
180	600	10.8	320
3360	600	10.8	320
6720	600	10.8	319

Under such conditions, the total cost of a d-c. installation may be as low as that with a-c. drives. This, with the undisputed advantages of simplicity, flexibility, and easy operation, has been responsible for the large proportion of tandem mills driven by d-c. motors.

Power Requirements

Tests have been made on many of the mills now in operation, so that the energy consumption and capacity of driving motors for any proposed new mill may be estimated with considerable accuracy.

There are two general methods of calculation. One, known as the displacement method has been described in detail in a paper before the Institute by Mr. Wilfred Sykes in 1912. By this method it is assumed that during a pass there is "displaced" a volume of metal equal to the product of the length before the pass and the difference in area before and after the pass, and that the energy used is proportional to this displaced volume. The unit energy consumption is determined by test, and increases as the temperature falls and steel becomes more dense during rolling, so that curves are plotted using the percentage of the original cross section area of the billet as the other coordinate. The curves shown on Fig. 8 are plotted from the average of data from a large number of tests on a 20-16 in. strip mill, rolling 3 in. thick billets to strip varying from 0.049 in. to 0.240 in. thick.

The other method of calculation is based on the energy required to elongate a unit volume or weight of steel, assuming the initial elongation before starting to roll as one. The curves shown in Fig. 9 are plotted from the same test data as Fig. 8.

The results by the two methods of calculation check quite closely, and such calculations enable the designer to quite accurately select motor drives for a similar proposed mill, although the data must be used with care, and due regard given to the effect of variable conditions, such as mill layout, rolling speed, temperature and analysis of steel to be rolled, percentage reduction per pass, etc., any or all of which may materially influence the power requirements. For

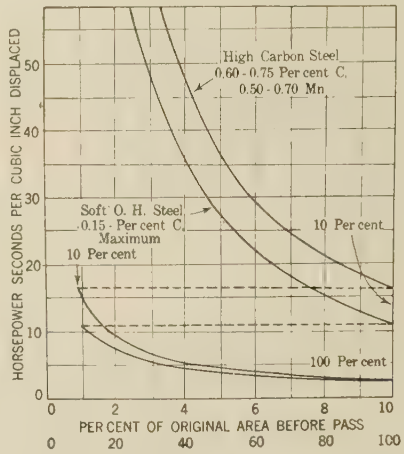

Fig. 8—Energy Consumption per Unit Displacement Curves for Rolling 3 In. Thick Billets to Strip on 20-16 In. Tandem Mill

instance, the effect of the carbon content of the steel is shown by the curves, the lower curve on each of the figures showing energy consumption for "soft open hearth" steel, with carbon up to about 0.15 per cent and the upper curve showing energy consumption for rolling

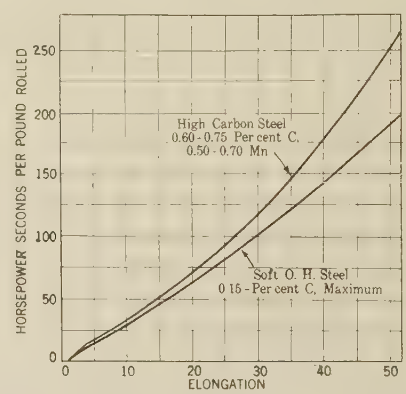

Fig. 9—Net Energy Consumption—Elongation Curves for Rolling 3 In. Thick Billets to Strip on a 20-16 In. Tandem Mill

steel with about 0.60-75 per cent carbon, and 0.50-70 per cent manganese. The high carbon and manganese steel requires over 30 per cent more total energy to reduce to 16 gage strip than does the soft steel.

Conclusions

The paper indicates that the tandem type of mill with individual stands separately driven by adjustable speed motors has great flexibility and is capable of rolling large tonnages, with very low labor operating costs. A-c. equipment may be used for drives, but d-c. motors

are in general more simple and have better characteristics, and where several drives are installed the cost may be as low or lower than for the a-c. drives. Test data from existing mills are available, and power requirements of any proposed mill may be quite accurately estimated and correct applications of driving equipment made.

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Mathematical Solution of an Unbalanced Three-Phase Voltage System

BY HORACE M. NORMAN

Member, A. I. E. E.

In the March, 1927 issue of the A. I. E. E. Journal there appeared a very interesting article on this subject by Dr. A. E. Kennelly.

Starting from an original geometrical construction, whereby the unbalanced system is resolved into its two balanced components of positive and negative sequence, the writer evolved the solution following:

Up to a certain point, this solution gives the equivalent of that shown in Dr. Kennelly's work, but for ordinary use, it is shown to have insufficient accuracy. Proceeding further, a formula is evolved which gives the value of the balanced negative sequence component of the unbalanced system without requiring any more accurate means of evaluating than the ordinary slide rule.

It is the value of this negative component which as a rule, is of more interest than the positive component.

Part I

In order to simplify the evolving of the mathematical formulas used for finding the positive and negative sequence balanced voltage systems which are the equivalent of some unbalanced system, the geometrical construction shown in Fig. 1 was utilized.

This shows an unbalanced voltage triangle $A_1 B_1 C_1$. Two medians $C_1 Q$ and $A_1 P$ are drawn and intersect at O, the center of the triangle $A_1 B_1 C_1$. A circle $A_1 C_2 R B_2$ is constructed with O as center and $O A_1$ as radius. The median $A_1 P$ is produced to cut this circle at R. Then with R as center and the same radius $O A_1$, a circle is drawn, which intersects the first circle at B_2 and C_2.

The length $B_2 C_1$ or $B_1 C_2$ gives the positive balanced component of voltage and the length $B_2 B_1$ or $C_2 C_1$ gives the negative component.

The reason for this is made clear by referring to Fig. 2.

Let O be the neutral of the system and $O A$, $O B$, $O C$ be the line to neutral vectors of the positive sequence balanced components; these are out of phase 120 deg. with each other. Then let $A A_1$, $B B_1$, $C C_1$ be the line to neutral vectors of the negative sequence system; these are also 120 deg. out of phase. The resultant unbalanced system is $A_1 B_1 C_1$.

If both these systems were of positive sequence, then the resultant should naturally be balanced. This is shown on the diagram by interchanging the vectors $C C_1$ and $B B_1$ and calling them $B B_2$ and $C C_2$. The

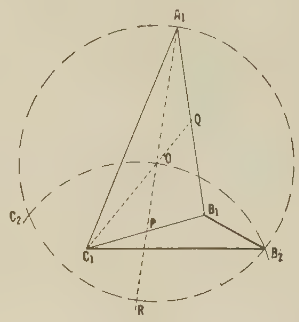


Fig. 1

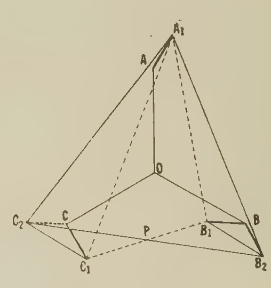


Fig. 2

resultant triangle $A_1 B_2 C_2$ is obviously balanced and must, therefore, be equilateral with O as its center.

The center of the triangle $A_1 B_1 C_1$ can also be shown to be at O.

Now, since $B B_2$ is equal and parallel to $C C_1$, and $B B_1$ equal and parallel to $C C_2$, then $B_2 B_1$ must be equal and parallel to $C_1 C_2$ and as a result of this, the two triangles $B_1 B_2 P$ and $C_1 C_2 P$ must be equal and, therefore, the point P must bisect both $B_1 C_1$ and $B_2 C_2$.

From this, it can be seen that if $B_1 C_1$ is bisected at P and an equilateral triangle $A_1 B_2 C_2$ constructed with

its center at O and its apex at A_1 then the points B_2 and C_2 are found and the length $B_2 C_1$ or $B_1 C_2$ which are each equal to $B C$ give the positive balanced voltage and the length $B_2 B_1$ or $C_1 C_2$ give the balanced negative voltage, all being line to line values. This is exactly what is done in Fig. 1.

Part II

Due to lack of space, the derivation of the following formulas, (1), (2), (3), and (4), is not given here, but they can easily be deduced from the foregoing geometrical construction.

Let e_1 be the line-to-line value of the positive sequence component.

Let e_2 be the line-to-line value of the negative sequence component.

$$e_1^2 + e_2^2 = \frac{1}{3}(E_1^2 + E_2^2 + E_3^2) = Y \tag{1}$$

$$e_1^2 - e_2^2 = \sqrt{\frac{1}{3}(E_3 + E_2 + E_3)(E_1 + E_2 - E_3)(E_1 - E_2 + E_3)(-E_1 + E_2 + E_3)} = Z \tag{2}$$

$$\therefore e_1^2 = \frac{1}{2}(Y + Z) \tag{3}$$

$$\text{and} \quad e_2^2 = \frac{1}{2}(Y - Z) \tag{4}$$

Upon inspecting equations (3) and (4), it is obvious that the value of e_1 can be found very accurately without undue care being taken to evaluate Y and Z. However, this is not so of e_2. Here half the difference of Y and Z gives the value of e_2^2 and unless Y and Z are found with great precision then little reliance can be placed on the value of e_2 so obtained.

It will be shown later that for values of $E_1\, E_2\, E_3$ of 400, 420, 440 volts if the constants Y and Z are found with an error of only 1/10th of 1 per cent, then a possible error of 33 per cent can be made in finding e_2^2 by equation (4).

From previous equations,

$$e_1^4 + 2\,e_1^2 e_2^2 + e_2^4 = (e_1^2 + e_2^2)^2 = \left\{\frac{1}{3}(E_1^2 + E_2^2 + E_3^2)\right\}^2$$

$$e_1^4 - 2\,e_1^2 e_2^2 + e_2^4 = (e_1^2 - e_2^2)^2 = \frac{1}{3}(E_1 + E_2 + E_3)(E_1 + E_2 - E_3)(E_1 - E_2 + E_3)(-E_1 + E_2 + E_3)$$

subtracting these two equations gives

$$4\,e_1^2 e_2^2 = \frac{4}{9}(E_1^4 + E_2^4 + E_3^4) - \frac{4}{9}(E_1^2 E_2^2 + E_2^2 E_3^2 + E_3^2 E_1^2)$$

$$18\,e_1^2 e_2^2 = (E_1^4 - 2\,E_1^2 E_2^2 + E_2^4) + (E_2^4 - 2\,E_2^2 E_3^2 + E_3^4) + (E_3^4 - 2\,E_3^2 E_1^2 + E_1^4)$$
$$= (E_1^2 - E_2^2)^2 + (E_2^2 - E_3^2)^2 + (E_3^2 - E_1^2)^2$$

$$18\,e_1^2 e_2^2 = \{(E_1 + E_2)(E_1 - E_2)\}^2 + \{(E_2 + E_3)(E_2 - E_3)\}^2 + \{(E_3 + E_1)(E_3 - E_1)\}^2 \tag{5}$$

The foregoing equation has three terms on the right hand side which must be positive even though the quantity inside the bracket may be negative, as they are all to the second power. Therefore, if through using the slide rule an error of 1/10th of 1 per cent were made in finding each term, the greatest error would still be 1/10th of 1 per cent.

The right hand side of the equation has to be divided by $18\,e_1^2$, which again introduces an additional error; but the total error would not exceed 3/10th of 1 per cent and this is more than sufficiently accurate for all general purposes.

Part III

To illustrate the comparative accuracies of equations (4) and (5) assume the following values of voltage:

$$E_1 = 400$$
$$E_2 = 420$$
$$E_3 = 440$$

$$\text{then } Y = \frac{1}{3}(400^2 + 420^2 + 440^2) = 176666.7$$

$$Z = \sqrt{\frac{1}{3} \times 1260 \times 380 \times 420 \times 460} = 175598.2$$

$$\text{From (3)} \quad e_1^2 = \frac{1}{2}(176666.7 + 175598.2) = 176132$$

$$e_1 = 419.6 \tag{6}$$

$$\text{From (4)} \quad e_2^2 = \frac{1}{2}(176666.7 - 175598.2) = 534.2$$

$$e_2 = 23.1 \tag{7}$$

$$\text{From (5)} \quad e_2^2 = \frac{1}{18 \times 176132}\{(820)^2(-20)^2 + (860)^2(-20)^2 + (840)^2(40)^2\}$$
$$= \frac{1}{18 \times 176132}(1693760000)$$
$$= 534.2$$
$$e_2 = 23.1 \tag{8}$$

Assuming accuracy of 1/10th of 1 per cent for the finding of Y and Z then equation (4) might have been:

$$e_2^2 = \frac{1}{2}(176843.3 - 175422.6) = 710.3$$

instead of 534.2 or 33 per cent high.

Assuming accuracy of 1/10th of 1 per cent for finding values for equation (5) then equation (5) might have been:

$$e_2^2 = \frac{1}{18 \times 176308.1}(1692066240) = 532.5$$

instead of 534.2. Error negligible.

Of course, when the slide rule is used, the first four are the only significant figures and the equation would be written:

$$e_2^2 = \frac{1}{18 \times 176300} (1692 \times 10^6)$$

$$= 532.5$$

The reason that the value of e_2^2 is taken as the basis for argument instead of e_2 is because the extra losses due to the presence of e_2 in the circuit are proportional to e_2^2.

The error in finding e_2 by equation (4) is less than 33 per cent, actually 15 per cent.

These formulas apply equally well to current systems.

Discussion

By Dr. A. E. Kennelly

(*Communicated*)

Mr. Norman's article is an interesting contribution to the discussion of the present writer's article *Computation of the Unbalance Factor of a Three-Phase Triangle when Lengths of Three Sides are Given*, appearing in the A. I. E. E. Journal of March, 1927, in which it was shown that d^2, the square of the forward equivalent balanced component is the half sum

$$\frac{A_m^2 + A_s^2}{2},$$

and e^2 the square of the backward equivalent component is the half difference

$$\frac{A_m^2 - A_s^2}{2},$$

where A_m^2 is the mean of the squares of the three unbalanced sides and A_s^2 is the square of the equilateral side of a balanced system having the same area as the unbalanced triangle.

Mr. Norman points out that when the system is not badly unbalanced, A_m^2 and A_s^2 may be large numbers, not far apart; so that small percentage errors in their computed values may lead to a relatively large error in e^2. For the case, he analyzes of 400, 420 and 440 volts, where the average of the divergences (20, 0 and 20) is 13.3 volts or 3.2 per cent, the strictly computed value of the backward balanced component is $e = 23.1$ volts and $e^2 = 534.2$; whereas opposite errors of only 1 per mil in the two quantities A_m^2 and A_s^2 change the result to $e = 26.7$ volts and e^2 to 710.3, errors of 15.6 and 33 per cent respectively. He shows that for technical reasons, e^2 is more important to ascertain than e simply; so that divergences of 1 per mil in arriving at A_m^2 and A_s^2, may produce 33 per cent error in estimating e^2. This indicates that the computation is not well adapted to slide-rule operation and that, in order to obtain correct numerical results, either a calculating machine, or logarithms, should be used. If, however, a slide rule is to be employed, the somewhat longer formula he suggests is distinctly to be preferred.

But there is another and independent consideration. If the three-phase system is not seriously unbalanced and the three side values are not very accurately measured, the observational defects may involve considerable error in the values of e and e^2; even if the computations are very precise. Thus, if one of the voltages in Mr. Martin's set should be taken 1 per cent low, and another 1 per cent high, (396, 420, and 444.4) the resulting backward component would come out $e = 27.99$ and $e^2 = 783$, instead of 23.1 and 534.2, respectively, excesses of 21 per cent and 46.6 per cent. These errors would appear with either type of formula accurately applied.

We may conclude, therefore, that when a three-phase system is only slightly out of balance, great care must be taken in measuring the three sides of the voltage triangle and in computing the results if we are to secure a precise value for the backward balanced component e, and still more so for e^2. The same conditions apply also to graphical methods.

ILLUMINATION ITEMS

By Committee on Production and Application of Light

HOW WE READ

Reading seems to be a simple process, but actually it is extremely complex. Even if all the psychological aspects involved are dismissed and the process is studied from the vision point of view only, the problem is still found to be difficult. However, enough research has been done so that the movements of the eyes in reading are fairly well known.

The eyes do not move at a uniform speed across the page. They jump from point to point, pausing in steady fixation several times across the ordinary five-inch line of print. For example, one reader made an average of 10 pauses per line, the duration of pause being 0.3 second; and during the pause, he read about 1.4 words. Usually, the number of pauses varies from 2 to 7. During the jumps, the eyes cannot possibly see any more clearly than stationary eyes can see rapidly moving print. Furthermore, during the movement, the connection between the eye and brain is apparently broken. This actually prevents seeing the objects, even blurred, as the eyes make their rapid sweep.

Fully 2000 measurements have been made upon a number of subjects and it has been found that the time the eye pauses in ordinary work is seldom greater than 0.3 second, or less than 0.075 second, and that the average duration of pause is 0.150 second.

In connection with these data on the details of seeing, it is interesting to note the effect of intensity of illumination upon the speed of the complete operation of reading. It has been found that—

(a) When the intensity of illumination was increased from 0.4 foot-candle to 4 foot-candles, the speed of reading increased 54 per cent.

(b) When the intensity of illumination was increased from 4 foot-candles to 16 foot-candles the speed of reading increased 15 per cent.

(c) When the intensities of illumination were increased up to 30 foot-candles, a still further improvement was shown, which indicated that the advantages of increased illumination extend even further.

Electrification of factories is proceeding at a rapid pace in the United States. Since 1919, the total increase of six and one-half million horse power in factories has been in electrical motors purchasing power from interconnected systems. Over 70 per cent of the total of 41,000,000-horse power prime movers in factories is now electrical. On the average, each factory wage earner is aided today by 4.3 horse power. This amount is twice as great as in 1910.

INSTITUTE AND RELATED ACTIVITIES

The Summer Convention at Denver, June 25-29

Details of Technical Sessions and Special Entertainment Features

A program of excellent technical papers and most enjoyable recreational features has been scheduled for the 1928 Summer Convention which will be held in Denver, June 25-29, with headquarters at the Cosmopolitan Hotel.

Technical Session

Subjects alive in the minds of engineers will be treated in the technical papers. They will include such topics as surge-voltage investigations on transmission lines, control and protection of feeders for electrified railways, a-c. elevator motors, electric welding of pipe lines, telephony, transmission experiences, extinction of a-c. arcs, high-frequency supervisory control and geophysical prospecting.

BENDER-SALT LAKE TELEPHONE LINE CROSSING THE CONTINENTAL DIVIDE

The year's advances in all lines of electrical engineering will be described in the annual reports of the Institute's Technical Committees.

Section and Branch Conferences

The annual conference of officers and delegates from Sections will be held on the first day of the meeting, and also there will be a conference of officers, Branch Counselors and delegates.

Annual Business Meeting of the Institute

The Annual Business Meeting of the Institute will be held at 9:30 a. m. Tuesday, June 26th, at the Cosmopolitan Hotel.

Trips

Chief among the entertainment features will be an all-day trip through Denver's mountain parks, on Thursday, June 28. Private cars will take members through the pioneer town of Golden at the foot of Lookout Mountain. The climb up the mountain will be over the famous "Engineers Lariat Trail," to an elevation of 7600 ft. At the top a stop will be made to visit the grave of Buffalo Bill and Pahaska Tepee, and to view the broad panorama of mountains and plains. The route will then lead over Genessee Mountain to Bergen Park and down the beautiful Bear Creek canyon on the return to Denver.

Trips may be made to the Valmont Steam Plant of the Colorado Public Service Company, broadcasting station KOA, stockyards and packing plants, and other interesting points.

In connection with the convention, a most attractive tour of Yellowstone Park and other places has been arranged to start immediately after the convention closes, June 29. Details of this trip follow the Tentative Program. Members may join this tour at any point along the route and also after reaching Denver. Information on these and other points in connection with the tour may be obtained from the Henry Tours, Inc., 565 Fifth Avenue, NewYork, N. Y., the agency handling the official tour.

Other enjoyable scenic trips may be taken out of Denver. Probably some who will not take the Yellowstone tour will take some of the other trips after the convention closes. The regular summer excursion rates from points east of the Missouri River includes a free side trip to Colorado Springs, the center of the Pike's Peak region, or to Boulder, the gateway to the Glacier district.

Popular Colorado side trips may be made as follows:

One-day trips through Boulder and the glacier region for $6.80 and $9.50.

One-day trip through the Moffat Tunnel, $6.50.

Two-day all-expense auto tour through Rocky Mountain National Park, Big Thompson Canyon and Lookout Mountain $33.00.

Three-day all-expense auto tour as above, except an extra night spent at Grand Lake, $39.00.

Attendants will be present at the Cosmopolitan Hotel headquarters so that reservations and travel information may be available.

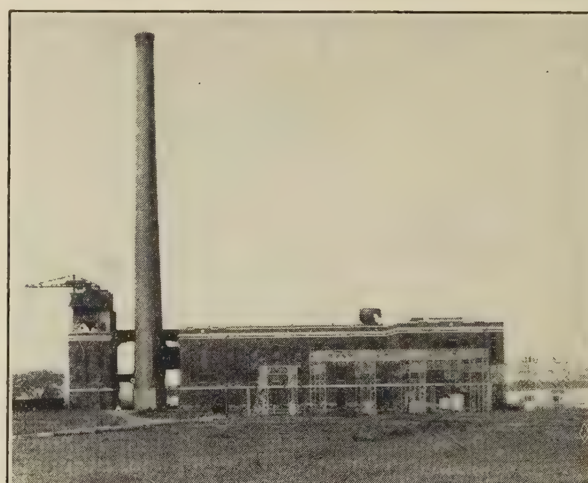
Entertainment

Golf and tennis tournaments will be played at the leading country clubs of Denver.

There will also be a reception and a dinner, both of which will be followed by dancing.

Ladies' Entertainment

The ladies attending will, of course, enjoy the events already mentioned, and in addition, special plans have been laid for their entertainment, including teas, card parties, sightseeing and shopping tours, golf, tennis, and swimming. The accompanying Ladies' Program gives a schedule of the events.



VALMONT STEAM PLANT, COLORADO PUBLIC SERVICE CO.

Railroad Rates

Regular summer excursion rates will be available for members who take the trip to Denver but do not participate in the Yellowstone tour.

Hotel Reservations

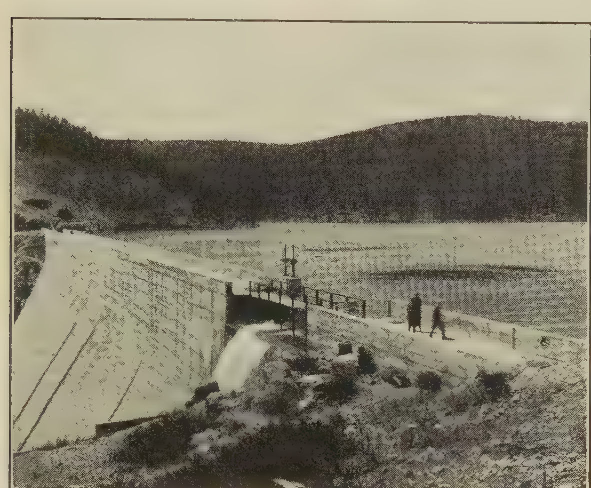
The new Cosmopolitan Hotel, with 460 rooms, has been designated Convention Headquarters. The following room rates have been established:

All rooms with bath. Most double rooms with twin beds.

Court rooms	single	$4.00	double	$6.00
Outside rooms	single	$4.50 $5.00	double	$7.00 $8.00
Corner rooms	double, $10.00 and $12.00			

Three-room suites for three to six persons, $25.00 to $30.00

Additional rooms have been arranged for at the Brown Palace Hotel, the Shirley-Savoy, and other hotels having comparable accommodations and rates. A limited number of single rooms with bath at $3.00 will be available within a few blocks of the Cosmopolitan, but it is expected that, as usual, the demand for single rooms will exceed the supply, and visitors are urged to arrange for sharing double rooms. Preferences for rooms outside the Cosmopolitan Hotel will be arranged for so far as possible, but, owing to other conventions in the city, they cannot be guaranteed in advance.



The Barker Reservoir of the Public Service Company of Colorado

Reservations should be addressed to the A. I. E. E. Hotel Committee, Cosmopolitan Hotel, Denver, Colorado, and can be made with the Committee's assurance that comfortable quarters will be provided in or near the Convention Headquarters hotel.

Those who take the Yellowstone Tour will have reservations made for them by the bureau which is handling the tour.

Committees

The General Convention Committee for the meeting is being directed by H. S. Sands, chairman; W. H. Edmunds, vice-chairman, and R. B. Bonney, secretary. The officers of the various sub-committees are as follows: *Entertainment*—B. Shubart, chairman; H. B. Dwight, vice-chairman; *Finance*—W. C. Sterne, chairman; G. E. McCarn, vice-chairman; *Meetings and Papers*—H. P. Charlesworth, chairman; L. N. McClellan, vice-chairman; *Registration*—A. L. Jones, chairman; W. C. DuVall, vice-chairman; *Sections*—W. B. Kouwenhoven, chairman; V. L. Board, vice-chairman; *Ladies Entertainment*—Mrs. A. L. Jones, chairman; Mrs. L. N. McClellan, vice-chairman; *Hotel*—H. B. Barnes, chairman; J. H. McCable, vice-chairman; *Publicity*—J. F. Greenawalt, chairman; H. H. Argabrite, vice-chairman; *Transportation*—W. H. Edmunds, chairman; G. M. Moore, vice-chairman; *Student Branches*—J. L. Beaver, chairman; H. S. Evans, vice-chairman.

TENTATIVE PROGRAM

Mountain Standard Time is indicated throughout this program

Monday, June 25

9:00 a. m.	Registration
10:00 a. m.	Section Committee Meeting
12:30 p. m.	Section and Branch Delegates' Luncheon
2:00 p. m.	Section Committee Meeting (Continued)
4:00 p. m.	Branch Committee Meeting

Tuesday, June 26

9:30 a. m. Annual Business Meeting of the Institute
President's Address
Presentation of Prizes for Papers
Technical Session on Surge-Voltage Investigations

Session A

Surge-Voltage Investigation on Transmission Lines, W. W. Lewis, General Electric Co.

Lightning Investigations on New England Power Company's System, E. W. Dillard, New England Power Co.

Surge-Voltage Investigation on 140-kv. System of Consumers Power Co., J. G. Hemstreet and J. R. Eaton, Consumers Power Co.

Surge-Voltage Investigation on 132-Kv. Transmission Lines of American Gas and Electric Co., Philip Sporn, American Gas & Electric Co.

Surge-Voltage Investigation on 220-kv. System of Pennsylvania Power & Light Co., N. N. Smeloff, Pennsylvania Power & Light Co.

2:00 p. m. Golf and Tennis Tournaments
8:30 p. m. Lecture, "Geophysical Methods of Prospecting" by Dr. C. A Heiland, Colorado School of Mines
9:30 p. m. Reception

Shoshone Power Plant—Public Service Company of Colo.

Wednesday, June 27

9:30 a. m. Technical Committee Reports, Sessions B and C

Session B

Research	F. W. Peek, Jr., Chairman
Electrophysics	Vladimir Karapetoff, Chairman
Education	P. M. Lincoln, Chairman
Instruments and Measurements	E. S. Lee, Chairman
Communication	H. W. Drake, Chairman

Production and Application of Light . . . . P. S. Millar, Chairman
Electrochemistry and Electrometallurgy . . . . . G. W. Vinal, Chairman
Electrical Machinery . . . F. D. Newbury, Chairman

Session C

Power Transmission and Distribution . . . . . Philip Torchio, Chairman
Protective Devices . . . . F. L. Hunt, Chairman
Automatic Stations . . . Chester Lichtenberg, Chairman
Applications to Iron and Steel Production . . . . . A. G. Pierce, Chairman
Applications to Mining Work W. H. Lesser, Chairman
Applications to Marine Work W. E. Thau, Chairman
Transportation . . . . J. V. B. Duer, Chairman
Electric Welding . . . . J. C. Lincoln, Chairman

12:30 p. m. Directors' Luncheon-Meeting
2:00 p. m. Technical Session on Electrified Railways

Session D

High-Speed Circuit Breakers, J. W. McNairy, General Electric Co.
High-Speed Circuit Breakers for Railway Electrification, H. M. Wilcox, Westinghouse Electric & Mfg. Co.
Operating Experience with High-Speed Circuit Breakers, B. F. Bardo, New York, New Haven & Hartford Railroad
Arrangement of Feeders and Equipment for Electrified Railways, R. B. Morton, of Gibbs and Hill
Protection of Electric Locomotives and Cars to Operate with High-Speed Circuit Breakers, E. H. Brown, Pennsylvania Railroad
The High-Speed Circuit Breaker in Railway Service, W. P. Monroe and R. M. Allen, Illinois Central Railroad

7:00 p. m. Convention Dinner-Dance

Thursday June 28

9:30 a. m. Mountain Trip (Returning about 4:30 p. m.)
8:00 p. m. Theater Party

Friday, June 29

9:30 a. m. Technical Sessions E and F

Session E

A Formula for Minimum Horizontal Spacing of Transmission-Line Conductors, P. H. Thomas, Consulting Engineer
Transmission Experiences of the Public Service Co. of Colorado, M. S. Coover, University of Colorado, and W. D. Hardaway, Public Service Co. of Colorado.
A-c. Elevator Motors of the Squirrel-Cage Type, E. E. Dreese, Lincoln Electric Co.
Electric Welding of Pipe Lines, J. D. Wright, General Electric Co.

Session F

Utilization of Lodgepole Pine as Pole Timber, R. W. Lindsay, Mountain States Telephone & Telegraph Co.
Carrier Systems on Long-Distance Telephone Lines, H. A. Affel and C. S. Demarest, American Telephone & Telegraph Co., and C. W. Green, Bell Telephone Laboratories, Inc.
Superimposed High-Frequency Currents for Circuit-Breaker Control, L. R. Ludwig, Westinghouse Electric & Mfg. Co.
Extinction of an Alternating-Current Arc, Joseph Slepian, Westinghouse Electric & Mfg. Co.

1:30 p. m. Golf and Tennis Finals
7:20 p. m. Start of Tour to Yellowstone Park, etc.

LADIES' PROGRAM

The ladies are invited to all events of the Convention. The following features are listed as being of special interest.

Monday, June 25

8:00 p. m. Informal Reception

Tuesday, June 26

10:00 a. m. Golf, Tennis, and Swimming
2:00 p. m. Drive around Denver and Tea and Entertainment at Cherry Hills Country Club
8:30 p. m. Lecture on "Geophysics" by Dr. C. A. Heiland, Colorado School of Mines
9:30 p. m. Reception and Dancing

Wednesday, June 27

11:00 a. m. Drive up Lookout Mountain, Luncheon and Bridge at Mt. Vernon Country Club, returning at 4:30 p. m.
7:00 p. m. Convention Dinner-Dance

Thursday, June 28

9:30 a. m. All-Day Mountain Trip, returning at 4:30 p. m.
8:00 p. m. Theater Party at the famous Elitch's Gardens

Friday, June 29

10:00 a. m. Finals in Golf, Tennis and Swimming
Afternoon Shopping and Other Trips
7:20 p. m. Start of Tour to Yellowstone Park, etc.

A. I. E. E. Tour to Yellowstone Park

The tour to Yellowstone Park, which will follow the Summer Convention in Denver, has created much interest among Institute members, quite a number of whom are planning to take the trip. Yellowstone National Park will be the main objective

Great Fall from Belon, Haynes, St. Paul

of the tour and stops will also be made at Colorado Springs and Salt Lake City.

About eighteen days will be required for the entire trip, including the Convention, if New York City is the starting point. The time required from other points will depend, of course, upon their location. The start will be made from New York

on the afternoon of June 22 and the return to New York will be on July 10.

Members from other sections of the country may meet the party at any point along the route including Denver.

The party will arrive at Denver on Sunday evening, June 24, and after the Convention is over, will leave Friday evening, June 29, for Colorado Springs, where they will stay at the Broadmoor Hotel.

Towers Along the Cody Road in Shoshone Canyon

These towers resemble the ruins of old buildings and this particular tower looks very much like a ruined church while on the distant hill is shown the broken cross

At Colorado Springs June 30, Pike's Peak, the Garden of the Gods, South Cheyenne Canyon, and Seven Falls will be visited. Enroute from Colorado Springs on July 1 will be seen the famous Royal Gorge.

Arriving in Salt Lake City on the morning of July 2, trips will be made morning and afternoon, and at noon the organ recital in the Mormon Temple will be heard. Among the trips which can be taken are those to Saltair Beach, the Bingham Copper Mines, and the canyons near the city.

Leaving Salt Lake City on the evening of July 2, the party will arrive at the West Yellowstone entrance on the next morning.

In Yellowstone National Park, four and one-half days will be spent enjoying the many wonders of nature which are there. Old Faithful and many other geysers, Yellowstone Lake, the Grand Canyon and Great Falls of the Yellowstone, Mammoth Hot Springs, Shoshone Lake and Dam are the prominent points that will be visited.

Leaving the park by way of the Cody road the party will take the train at Cody on the evening of July 7 and will arrive in Chicago, July 9 and in New York, July 10.

A detailed schedule of the tour is included at the foot of this announcement.

A most enjoyable feature of this trip will be that all arrangements for railroad and pullman tickets, hotels, automobile tours, baggage transfer, etc., will be made by the travel bureau which has been authorized for the trip.

The cost of the tour, depending on pullman accommodations desired, will be as follows, with New York as the starting point. Rates from other points will differ according to the location.

COST OF TOUR STARTING AT NEW YORK

One in upper berth	One in lower berth	Two in compartment (each person)	Two in drawing room (each person)	Three in drawing room (each person)
\$350	\$375	\$398	\$439	\$393

The tour is arranged on the all-expense plan and the cost includes round-trip railroad and pullman transportation, side trips, accommodations at first-class hotels (rooms with bath, twin beds) including the Cosmopolitan Hotel, the headquarters of the meeting, all meals (except at Denver), transfer of passengers and baggage, sight-seeing and touring cars, in fact all necessary expenses except meals at Denver, trips in Salt Lake City and tips.

The cost does not include private baths at Yellowstone Park. Such accommodations are limited, but private bath accommodations will be secured, at slight additional cost, for members of the party who desire them there.

All who are interested in this tour are requested to communicate with the travel bureau, The Henry Tours, Inc., 565 Fifth Avenue, New York, N. Y., which will make arrangements. The bureau will give information on all matters.

SCHEDULE OF YELLOWSTONE TOUR

June 22 (Fri.)	Lv.	New York (N. Y. Central, No. 41)	1.00 p. m.
23 (Sat.)	Ar.	Chicago	1.00 p. m.
		Auto trip about the city	
	Lv.	Chicago (Chicago, Burlington and Quincy, No. 1)	5.30 p. m.
24 (Sun.)	Ar.	Denver	7.55 p. m.
25 (Mon.) to 29 (Fri.)		Attending Convention, Cosmopolitan Hotel	
29 (Fri.)	Lv.	Denver (Denver & Rio Grande Western, No. 15)	7.20 p. m.
	Ar.	Colorado Springs	9.45 p. m.
		Overnight at the Broadmoor Hotel	
30 (Sat.)		At Colorado Springs. In the morning auto trip to summit of Pike's Peak. In the afternoon auto trip to Garden of the Gods, South Cheyenne Canon and Seven Falls. Meals and overnight at the Broadmoor.	

Pulpit Terrace Yellowstone Park

July 1 (Sun.)	Lv.	Colorado Springs (D. & R. G. W. No. 7)	10.10 a. m.
		Short stop enroute at Royal Gorge.	
2 (Mon.)	Ar.	Salt Lake City	9.15 a. m.
		Luncheon and dinner at Hotel Utah.	
	Lv.	Salt Lake City (Union Pacific No. 45)	8.00 p. m.

	3 (Tues.)	Ar.	West Yellowstone	7.30 a. m.
		Lv.	West Yellowstone (auto)	9.30 a. m.
		Ar.	Old Faithful	11.55 a. m.
July	4 (Wed.)	Lv.	Old Faithful (auto)	1.50 p. m.
		Ar.	Yellowstone Lake	4.55 p. m.
	5 (Thur.)	Lv.	Yellowstone Lake (auto)	10.00 a. m.
		Ar.	Grand Canyon	12.00 Noon
		Lv.	Grand Canyon	1.30 p. m.
		Ar.	Mammoth Hot Springs	4.48 p. m.
	6 (Fri.)	Lv.	Mammoth Hot Springs (auto)	12.30 p. m.
		Ar.	Grand Canyon	3.00 p. m.
	7 (Sat.)	Lv.	Grand Canyon (auto)	9.00 a. m.
		Ar.	Sylvan Pass Lodge	12.01 p. m.
		Lv.	Sylvan Pass Lodge (auto)	1.15 p. m.
		Ar.	Cody Inn	4.55 p. m.
		Lv.	Cody Inn (C. B. & Q. Yellowstone Park Comet)	8.30 p. m.
	8 (Sun.)		Enroute (on Northern Pacific to Minneapolis)	
	9 (Mon.)	Ar.	Minneapolis	6.40 a. m.
		Lv.	Minneapolis (No transfer) (C. B. & Q. No. 52)	7.05 a. m.
		Ar.	Chicago	7.55 p. m.
		Lv.	Chicago (N. Y. C. No. 40)	9.00 p. m.
	10 (Tues.)	Ar.	New York	6.50 p. m.

Pacific Coast Convention in Spokane August 28-31

The 1928 Pacific Coast Convention to be held August 28-31 at Spokane, Wash., will have on its program some very timely technical papers. Among the subjects to be discussed are transmission studies including lightning phenomena, corona, and swinging of conductors; carrier-current relaying and communication; automatic stations; vacuum-tube applications; telephony, railway electrification, automatic train control, electrometallurgy of zinc, etc.

Details will be published in a later issues of the JOURNAL.

Atlanta Regional Meeting October 29-31

A three-day regional meeting will be held under the direction of the Southern District of the Institute, in Atlanta, Ga., October 29-31, with headquarters at the Hotel Biltmore.

Tentative plans for a program have already been formed by the District Committee and further announcements will be made in future issues of the JOURNAL.

Annual Meeting of A. S. T. M. June 25-29

The thirty-first Annual Meeting of the American Society for Testing Materials will be held at Atlantic City, June 25-29, with headquarters at Chalfonte-Haddon Hall. The meeting will be comprehensive in its committee reports, besides the presentation of many papers on technical subjects of current interest. On the afternoon of Wednesday, June 27, at 4:00 o'clock, the third Edgar Marburg Lecture will be delivered by Doctor Frank B. Jewett, who has chosen for his subject, *Some Research Problems Involved in Transoceanic Telephony.* This Lecture was established in 1926 "for the purpose of having described before the Society by leaders in their respective professions, outstanding developments in the promotion of knowledge of engineering materials."

Abundant provision has been made also for the social side of the meeting, with an informal dance and smoker Wednesday evening, special recreation committee plans, golf and tennis tournaments.

Papers for World Congress

The importance of a careful selection of papers to be read to reflect the status and tendencies of each of the major branches of engineering in this country was stressed in the report of the Technical Program Committee of the World Congress, headed by Prof. Dugald C. Jackson. The program group will call on the societies specializing in the different branches of industry, for help in selecting authors for the American engineering papers. Since their acceptance would interfere with the adequate presentation of the larger developments of engineering in the United States, miscellaneous papers will not be received for reading at the Congress.

Professor Jackson, as chairman, announced thef ollowing as members of the technical program committee: Allen Hazen, vice chairman; H. Foster Bain, Alex Dow, W. F. Durand, J. R. Freeman, Bancroft Gherardi, George W. Fuller, F. L. Hutchinson, Major General Edgar Jadwin, Dean Dexter S. Kimball of the School of Engineering of Cornell University; A. D. Little, Fred R. Low, O. C. Merrill, Professor Michael I. Pupin, Calvin W. Rice, George T. Seabury, George Otis Smith and W. E. Wickenden.

Automotive Engineers to Meet in Quebec

This summer's semi-annual meeting of the members of the Society of Automotive Engineers will be in Quebec, with sessions from June 26 to 29, inclusive, at the Chateau Frontenac. The program now being planned provides for nine technical sessions, sightseeing trips about the city, golf and tennis, and a grand ball.

An international aspect will be given to the meeting by the attendance and presentation of addresses by several Canadian and European engineers. This will be in keeping with the old world character of the city in which the meeting is held, Quebec, the only typically European city on the American Continent.

Special trains will run from Detroit and New York City to carry members to the meeting, and a number of special cars from other cities will connect with these.

Canada to Hold Steel and Power Show Sept, 4-7

The outstanding event of the Canadian engineering world for 1928 will be Canada's Steel and Power Show which will be held in the University of Toronto Arena September 4 to 7, inclusive. Cooperating in the undertaking are the Canadian Section of the American Welding Society, the Engineers' Mutual Benefit Fund, the Canadian Engineering Standards Association, the Industrial Accident Prevention Association, and the Montreal Chapter of the American Society for Steel Treating.

Three New Standards and a Report Available

Section 4—Test Voltage in Dielectric Tests. This Section of the Standards was prepared by a subcommittee of the Standards Committee under the chairmanship of F. W. Peek, Jr. It was adopted by the Board of Directors on May 18, 1928. The Standard lays down conditions for the measurement of test voltages with voltmeters, spark-gaps, use of sphere- and needle-gaps, gives a table of sphere-gap spark-over voltages, and also covers testing equipment and arrangement, etc. Cost of pamphlet 30 cents; 50 per cent discount to members.

Section 15—Industrial Control Apparatus. This is a revision of the American Standard for Industrial Control Apparatus. The revision was made by the Sectional Committee procedure of the American Engineering Standards Committee and under the joint sponsorship of the National Electrical Manufacturers Association and the A. I. E. E. The revision was approved by the Board of Directors of the Institute on December 6, 1927 and received approval as an American Standard April 25, 1928. This standard covers the following types of apparatus: Industrial Motor Control; Similar Control used for Industrial Heating; Rheostats, including those for Generator Fields; Auto Trans-

formers used with Starters. Cost 40 cents; 50 per cent discount to members.

Section 36—Storage Batteries. This Section of the Standards was prepared by a subcommittee of the Standards Committee under the chairmanship of G. W. Vinal of the Bureau of Standards. It was approved as an Institute Standard by the Board of Directors on February 16, 1928. The standards in this Section apply to storage batteries of the lead-acid type and of the nickel-iron alkaline type. They are suitable for large and small batteries in either stationary or portable service. Cost 20 cents; 50 per cent discount to members.

Section 17 G1—Report on Standards for Letter Symbols of Electrical Quantities. This report which was given preliminary publication in the March 1928 JOURNAL was prepared by a subcommittee of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations, for which the Institute is one of five joint sponsors. Copies of this report may be obtained without charge by applying to Institute Headquarters. All criticisms and suggestions should be sent to H. E. Farrer, Secretary, Standards Committee, A. I. E. E., 33 West 39th Street, New York, N. Y.

Report on Technical Sessions at Baltimore Regional Meeting

The following is a digest of the discussion on the technical sessions of the Regional Meeting held in Baltimore, April 17-20, 1928. The complete discussion will be published with the corresponding papers in the TRANSACTIONS. A report on the other activities of the meeting was published in the May JOURNAL, p. 378.

SESSION ON INSULATION AND DIELECTRICS

Thermal Method of Standardizing Dielectric Power-Loss Measuring Equipment, J. A. Scott, H. W. Bousman and R. R. Benedict.

Residual Air and Moisture in Impregnated Paper Insulation—II, J. B. Whitehead, W. B. Kouwenhoven and F. Hamburger, Jr.

Developments in the Insulation of Coils for High-Voltage Turbo-Generators, C. H. Hill.

In discussing the first paper, W. F. Davidson warned that care must be taken in dielectric loss measurements to connect the guard circuit to the proper point so that errors will not be introduced. In a written discussion, Donald Bratt pointed out that the temperature rise on the surface of the cable sheath due to dielectric power loss is significant not only for its average value over a considerable length of cable but also for its fluctuations along this length. A study of these fluctuations will give an indication of the homogeneity of the insulation. He suggested also that it might be desirable to have a factory test whereby the non-homogeneous sections of insulation might be detected without cutting the cable. This could be accomplished by passing current first through the cable conductor and then through the sheath. If the temperature-rise curve differs materially in the second case from that found in the first case, this variation might be ascribed to heterogeneous insulation. H. L. Curtis, in discussing the first and second papers, asked if the loss attributed to humidity might be a loss across the insulators of the air condenser. In answering this, W. B. Kouwenhoven stated that with the latest type of condenser which he uses, there is no conduction loss across the insulation, and that tests at Johns Hopkins indicate clearly that losses due to humidity are caused by the presence of dust in the air. This was corroborated by J. B. Whitehead, who stated that he has no faith in the suggestion that humidity or temperature can cause any departure of the power factor of an air condenser from zero value. Alexander Nyman stated that he had made tests in connection with impregnated paper condensers and that his results were very similar to those described in the second paper. He stated that he had tested these condensers during the summer months and found that the effect of temperature was quite marked and was greater than that of humidity. The condensers he tested were completely impregnated in wax and yet moisture was able to penetrate the wax and cause leakage. He agreed that moisture does not have to be extracted from the paper previous to impregnation, but pointed out that in manufacturing processes it may be preferable to extract the moisture before impregnation. A. W. Gray, in discussing these papers, presented a theory to explain the action of dielectrics. According to this theory, any insulator is composed of insulating layers of the dielectric between which are small spaces. When voltage is first applied, there is a charge resulting from the geometric capacity. As the voltage is increased to a sufficient gradient, the small spaces between insulating layers become conductive. In other words, this theory assumes that air spaces within the insulation offer leakage paths and also gaseous ionization which lead to the ordinary phenomena of dielectric absorption. S. J. Rosch drew attention to the fact that the tests were made under laboratory conditions and that it is practically impossible to duplicate the results in cables which have been manufactured and installed. Several other discussors also called attention to the difficulty of getting such results in practical cables. W. S. Clark pointed out that the oil-filled cable comes nearer to the perfect cable than any other commercial one. He stated that of course the selection of this cable depends upon economic factors, and particularly for lower voltages it might not be economical. F. M. Clark stated that in the manufacture of capacitors the requirements are even greater than those mentioned in the second paper with regard to dryness of insulation and stability of power factor. D. W. Roper mentioned that the results of tests made at the University of Illinois on cable samples seem to show that an increase of power factor with time (particularly in the first few minutes) at constant potential, may indicate a good quality of dielectric. R. W. Wiseman referred to the fact that by drying paper too thoroughly its physical strength is destroyed and that therefore a compromise between physical and electrical strength must be made. From a cable manufacturer's point of view he thought that 0.1 per cent moisture was a good compromise point. He disagreed with the conclusion that sharply rising curves and rapid changes in power factor are due exclusively to entrapped air. He stated that the nature of the compound or of the paper has considerable effect on the changes in power factor.

In his closing comments, Dr. Whitehead pointed out that his experiments had been made only for the purpose of getting fundamental facts and that his paper did not endeavor to show how these facts should be applied in manufacturing cables.

In discussing the paper by Mr. Hill, P. L. Alger agreed that armature insulation depends on two factors: (1) the sticker, and (2) corona. The sticker, he stated, must combine the two requirements of flexibility and high temperature resistance. He agreed with Mr. Hill that black asphalt gives the best results. For prevention of corona, he stated, a simple asbestos-tape armor on the outside of the coil is quite satisfactory. He mentioned however that considerable corona can be permitted without giving much operating trouble.

SESSION ON GOULD ST. GENERATING STATION

The Gould St. Generating Station of the Consolidated Gas Electric Light and Power Company, A. S. Loizeaux.

Design Studies for Gould St. Generating Station, F. T. Leilich, C. L. Follmer and R. C. Dannettel.

Operating Experiences, Gould St. Generating Station, A. L. Penniman and F. W. Quarles.

In opening the discussion, A. G. Christy pointed out some of the novel features of the Gould St. Station. He stated that this is the first large American station built on the basis of one boiler for each turbine and that the performance has been quite satisfactory. The capacity of the turbines for the size of frame is somewhat larger than has been common in older stations. The

use of the condenser with long tubes rolled at both ends is a decided advance also, though such a scheme has been used in Europe but with very short tubes. The hairpin, vertical-type heater is unusual, takes up very little room, and is very accessible. The air preheaters are very large and Professor Christy predicted that larger air preheaters will be used as stations grow in size, because their advantages have become well recognized. He drew attention to the fact that the boiler house is considerably smaller than the turbine room and predicted therefore that larger machines will be used when additional units are installed. L. W. W. Morrow commented on the new features, particularly the boiler-per-turbine combination, the high rating, and the all-metal furnace wall. He pointed out that the success of this station means that we need not fear that fixed charges will be increased tremendously by departures from older practise such as use of high pressures and high temperatures and other refinements. He asked the authors if the maintenance of the automatic equipment of the station requires far more skillful operators and how many men per shift are employed. He also asked what would be the use factor expected out of the boiler-per-turbine combination. H. C. Sutton mentioned that several features of the station seem conservative in design, namely, the 450-lb. boiler pressure and 440 volts for the station auxiliaries. One advantage in using the 440-volt auxiliaries, he said, is that air type circuit breakers may be used instead of oil circuit breakers which are necessary for 2300-volt auxiliaries. R. L. Thomas pointed out the amount of attention which had been paid to over-all economy of this plant, and that due consideration had been given to the cost of equipment as well as efficiency, fuel rates, etc. He asked how boiler pressures at the station are allowed to decrease during banking and if intermediate firings are carried out. J. C. Strott drew attention to the fact that the plant occupied an unusually small area of ground. F. O. Schnure asked the authors if it is necessary to use all of the 53 points on the induced-draft fan control, and also what method is used in grounding the generators. M. M. Price, in commenting on the conservativeness of design, brought out the fact that the station was designed and the apparatus was purchased in 1924, and that a boiler pressure of 450 lb. was high at that time.

A. L. Penniman, Jr. in his closing discussion, emphasized the fact that though minor troubles had developed, most of these had been remedied and the station is doing substantially what it was designed to do. The air pre heaters, he said, are not doing what they were supposed to do because laboratory experiments indicated higher rates of heat transfer than it has been possible to obtain in practise, and there seems to be a definite indication that the heat loss by radiation from the generating units is somewhat larger than was anticipated. On the other hand, he said, the heat absorption of the boilers is apparently better than was anticipated, and the steam temperature has now been raised so that the efficiency is still higher than that shown in the curves of the paper. One conclusion which he has reached is that if pulverized coal is to be used, the plant should not be started cold weather on account of the difficulty of getting the drying system into correct operation. Particularly with the mill system, he said, the coal must be dry, and when it is dry, practically all problems of feeding, transporting, and grinding will disappear. The logical place to dry the coal, he stated, is in the mill. At Gould St. the air is fed in at about 400 deg. fahr., and the reduction in temperature due to evaporation of the moisture in the coal is so rapid that there is a 30-deg. fahr. drop in about 12 in. of travel of the air; actually, the temperature in the mill does not exceed the normal temperature without air drying by more than 5 deg. He stated he is convinced that there is no reason why the steam temperature should not be 800 deg. or 825 deg. in the next installation. This is the greatest opportunity for gain in economy at relatively small expenditures, and no trouble is to be expected from the superheaters by operating at 100 deg. higher temperature.

In answering Mr. Morrow's questions, F. W. Quarles stated that about fourteen men are used per shift and that the maintenance required for the automatic equipment has been comparatively small on the standardized pieces except on the draft-fan controls, on which there has been some trouble with interlocks. On new designs of equipment the maintenance has so far been high but with time this will decrease. He stated that at the present time no definite figures can be given on the use factor of the boilers and turbines. He said that the amount of fuel required in banking has not been measured, but that in banking, the pressure is allowed to fall to about 100 lb. and then raised again by the use of burners about every four hours. In regard to using the 53 points on the induced-draft fans, he stated that there is a great necessity for having a large number of points because of the large range in speed that is required.

A. S. Loizeaux, in answering Mr. Schnure's question, stated that the generators are solidly grounded though it is expected to insert a reactor in the 60-cycle system as has been done in the 25-cycle system, where a $\frac{3}{4}$-ohm reactor is used. Operation has proved, he stated, that there is no excessive smoking at high capacities of the boilers, and in fact that combustion then seems to be more complete.

Sessions on the Conowingo Development

The Conowingo Hydroelectric Development on the Susquehanna River, Alex. Wilson.

Electrical Features of the Conowingo Generating Station and the Receiving Substations at Philadelphia, R. A. Hentz.

The 220-Kv. Transmission Lines for the Conowingo Development, P. H. Chase.

Telephone System in Connection with the Conowingo Development, W. B. Beals and E. B. Tuttle.

Quantitative Mechanical Analysis of Power-System Transient Disturbances, R. C. Bergvall and P. H. Robinson.

Superexcitation for the Synchronous Condensers for the Conowingo System, D. M. Jones.

In commenting on these papers, F. G. Baum stated that the interesting thing about the Conowingo Development is the speed at which the work was done. He approved very heartily of the adoption of 220 kv. for the lines instead of a lower voltage. Five years' experience with 220 kv. in California, he stated, has shown very successful results. He stated that service should be figured not on interruptions per mile of line but per million kilowatt-hours delivered, and that value certainly will be much less at 220 kv. than at 110 kv. or a lower voltage. R. L. Thomas explained the location of the dam, pointing out that studies proved that there would be a very considerable gain accomplished by maintaining a pond level at Conowingo considerably higher than would be allowable if no interference were permitted with levels at Holtwood. He pointed out that arrangements for this were satisfactorily made between the two independent operating companies, and that it is gratifying that a good engineering proposition could be thus put through by good business cooperation. P. L. Alger drew attention to a novel feature of the design of the generators made by his company for this development. In these generators the entire rotor is made of riveted and plate construction without any castings whatever. He stated that it is expected that the efficiency of the generators at full load under rated conditions will be about 97.7 per cent. D. W. Roper asked if any special inducements were offered to the contractors to hasten the completion of the plant. In answering this question, Alex. Wilson said that no bonuses were offered to the contractors but that they all worked on a fee basis. The work was very carefully scheduled and there was complete coordination of construction progress, and no deviations were accepted. He stated also that fortunately such floods as occurred during the construction came at times when they did not delay the work.

R. A. Hentz pointed out one difficulty in designing the 220-kv. line which is not found on the Pacific Coast; namely, the severity

of lightning in this section of the country. This has been guarded against in three ways: (1) the insulation on the transformers is heavier than customary, (2) ground wires are installed over the transmission lines, and (3) lightning arresters are used on both ends. The selection of 440 volts for auxiliaries was made because building space is limited, and on account of the size of the motors it was found that 440 volts would be ample. He stated that his company feels very favorable toward 2300 volts for auxiliaries and uses it in all steam stations where the amount of power required is greater.

B. Van Ness asked the authors of the papers if their studies showed that the installation of quick excitation for the Conowingo plant would necessitate installing quick excitation on other existing stations in order that the excitation would be uniform throughout the system. L. G. Smith asked if consideration had been given to the fact that the steam governors may start to function during a period of oscillation and thus superimpose their effect on the oscillation of the system. He asked also if, after a short circuit had been removed from the system, it is necessary to prevent overvoltage on the synchronous condensers which may cause failure of insulation on some part of the system. F. G. Baum, in speaking of the advantages of synchronous condensers, said that they are valuable, first, in increasing the power capacity of the transmission line, second, in increasing stability, and third, in allowing a simplified method of voltage regulation by the system operator. F. C. Hanker brought out that one reason for preferring the loose-link system of interconnection, is that the equipment now developed does not permit separation of faulty circuits sufficiently quickly to prevent trouble. He believes that further operating experience is necessary before a decision can be made as to which of these two systems is most desirable. Alex. Bauhan pointed out that the question of stability did not really enter into the economic determination of the feasibility of this particular interconnection, because the distances are short and the stability limits are higher than the loads which were necessary to justify the interconnection. He stated, however, that on long-distance transmission of large amounts of power, stability is perhaps the controlling feature. It was his opinion that in this interconnection, the effect of voltage which dips in one part of the system, being transmitted to other parts, will probably cause considerable trouble, and that the number of dips will be greater than would have occurred without interconnection. However, he did not regard these voltage variations as very important. As to their effect on industrial applications, he stated that he believed that in the future all new industrial insulations, where continuity of service is important, will have their low-voltage releases provided with time delays. In referring to quick excitation, P. H. Robinson stated that it was possible to build up the fields quickly enough to cause a natural period of oscillation practically the same as that of the system, which might result eventually in a pull-out. He said that the condensers for the Plymouth Meeting Station had been designed so that this trouble would be avoided. He pointed out that in order to obtain the full advantages of quick excitation, it was found necessary to laminate the frames of the main exciters. A. F. Bang questioned the advisability of locating the substation on the top of the building, especially as this location limits the extension of the substation when other transmission lines are connected. He also mentioned the disadvantage of this location in regard to the possibility of oil fires in connection with the oil switches. He asked also why reactors were not installed on the system. Furthermore, he suggested that the transmission lines should not be operated in parallel on the high-tension side, in order that there would be less chance of falling out of step in case of short circuit. In speaking on Mr. Jones' paper, R. D. Evans pointed out that the curves are based on the assumption of constant terminal voltage which does not exactly correspond to operating conditions. F. A. Allner asked if it was not risky to install oxide-film arresters on the lines on account of the high-speed excitation and at times overexcitation, together with the possibility that in case of large loss of load, the water-wheel generators might speed up. In speaking of stability, Raymond Bailey said that it is very desirable that means be found to isolate faulty sections more quickly, and probably this should be accomplished by developing circuit breakers that function more quickly and relay protective systems which do not depend on time for their operation. P. H. Robinson, in answering a question, stated that in any large generating station of prime importance in the interconnection, the application of quick-response excitation will undoubtedly be of value. He stated that he did not believe that the effect of the reactive kv-a. would be to increase to dangerous proportions, the oscillations on the system. He said he did not believe that governors, if properly adjusted, would cause any bad effect following the opening of a short circuit. R. C. Bergvall, in answering a question of Mr. Bang, regarding the use of the transformers as reactors to cushion short circuits, stated that in some cases this practise would be of value and in other cases it would be a disadvantage, and that every case should be studied by itself. In answering Mr. Allner's question regarding lightning arresters, he stated that arresters of any type must be set within the maximum over-voltage obtainable on a system; otherwise the arresters will fail. The arresters on this system, he stated, are set for an increase of about 75 per cent in the line-to-neutral voltage. He said it was found that a reasonable degree of protection would result from an arrester installed on this basis, and that if experience indicates that the calculated over-voltages are not obtained, it is readily possible to cut out sections of the arrester. D. M. Jones pointed out what he thought was one disadvantage of the mechanical analog described by Messrs. Bergvall and Robinson, in that it is devoid of large amounts of friction which would correspond to certain factors in an actual transmission system. In referring to Mr. Smith's query, he agreed that overvoltage caused by excessive excitation applied to synchronous condensers, is one of the distinct limitations that exist in raising excitation to abnormal values. He agreed with Mr. Bang's point in regard to the addition of reactors, as these are of advantage in limiting the path of faulty current without limiting the path of power flow. R. A. Hentz, in answering a question of Mr. Bang, stated that the substation had been placed on the roof at Conowingo as a matter of economy. If not placed on the roof, the substation would have been located at the top of the hill quite a distance from the main station, and this would have been considerably more expensive. He added one more thought on the question of reactors, pointing out that 220,000-volt reactors are very expensive. He brought out another point in connection with over-voltage caused by over-speed of the generators, namely, that the generators have a mechanical over-speed device which trips the generator circuit breakers.

In discussing the paper by Beals and Tuttle, Mr. Markley asked if it is possible to connect the telephones in the buildings throughout the trunk line with the Philadelphia load-dispatching system. He pointed out the advantage of the location of the Conowingo station in that most of the communication circuits are underground. He asked if carrier current and short-wave space radio had been considered for communication on this system. Mr. Beals, in answering the first question, said that the Conowingo station operator has a direct circuit to the Philadelphia load dispatcher. A second circuit runs between the Conowingo plant and the private exchange branch of the Philadelphia Electric Company. He pointed out that one factor which led to the adoption of the telephones was that the Philadelphia Electric Company already had an extensive load-dispatching system and the Conowingo system is simply an extension of the Philadelphia system. E. B. Tuttle stated that carrier current had not been used at Conowingo because it was more expensive than the rented communication service. He said that .short-wave radio for distances less than two or three thousand miles is

still in an experimental stage, and that some power companies who wish to have a permanent record of all dispatching orders, employ the printing telegraph. Mr. Allner mentioned that on the Pennsylvania-Baltimore system, such a record is obtained by attaching a dictaphone to the telephone. Mr. Tuttle pointed out that this has the disadvantage of the operator having to change records sometimes in the middle of a conversation.

New Haven Regional Meeting a Marked Success

The fifth Regional Meeting of the Northeastern District of the Institute which was held May 9-12 with headquarters at the Hotel Taft, New Haven, Conn., was a marked success. Over 500 members and guests attended, and a large proportion of these were present at each technical session, inspection trip, and entertainment event.

The program included 18 papers as described in a summary of the sessions given in later paragraphs of this report.

There were, too, several very instructive inspection trips including those to the new electric motive-power equipment of the New York, New Haven & Hartford Railroad at New Haven, mercury arc rectifier substations of the Connecticut Company at Bridgeport, frequency-converter substations of the Connecticut Company at New Haven, and the Connecticut Light and Power Company at Devon, a mercury boiler and turbine installation of the Hartford Electric Light Company, the Hartford Hump Yard of the New Haven Railroad and the Rocky River Hydroelectric Development of the Connecticut Light and Power Company at New Milford.

A Student Branch Conference and Student Technical Session were noteworthy features of the meeting. A more complete report of these will be found in the Student-Activities department of this Journal.

An informal reception, with cards and dancing, a Convention dinner, and a theater party were the outstanding entertainment events in addition to numerous drives and teas scheduled specially for the ladies in attendance. The golf tournament was another popular feature.

At the Convention dinner held on the evening of May 10, H. M. Hobart, vice-president of the Northeastern District as official toastmaster, introduced Dean Charles H. Warren of the Sheffield Scientific School, who spoke on the origin and development of the engineering college at Yale. R. F. Schuchardt, presidential nominee of the Institute, then made a short address and, in turn, introduced Professor C. F. Scott of Yale University, who conferred the three Regional Prizes for papers presented during 1927 in the Northeastern District. A full account of these prize awards is published elsewhere in this Journal.

Professor Richard S. Lull of the Peabody Museum was the last speaker of the evening. He gave an illustrated lecture on the history and romance of sailing ships.

The theater party on the evening of May 11 was at the University Theater, where the Department of Drama of the School of Fine Arts, Yale University, presented a discussion and a demonstration of stage lighting followed by two one-act plays, writted and acted by students of the Department.

Digest of Technical Sessions

The following is a summarized report of the discussion of the technical discussions. The complete discussion will be published with the corresponding papers in the Transactions.

Symposium on Surge Measurements and Protective Devices

1. *Application of Relays for Protection of Power System Interconnections*, L. N. Crichton and H. C. Graves.
2. *Application of Wound-Type Current Transformers to High-Voltage Circuit Breakers*, J. C. Rea.
3. *Relation Between Transmission-Line and Transformer Insulation*, W. W. Lewis.
4. *Rationalization of Transmission—System Insulation Strength*, Philip Sporn.
5. *Hall High-Speed Recorder*, C. I. Hall.
6. *Pages from the Hall High-Speed Recorder*, E. M. Tingley.
7. *Oscillograph Recording of Transmission-Line Disturbances*, J. W. Legg.
8. *High-Speed Graphic Voltmeter*, A. F. Hamdi and H. D. Braley.

In discussing the first paper, O. C. Traver stated that one of the objections to the impedance relay scheme is its cost. He mentioned that the carrier-current system of protection is being tried out on the system of the Ohio Power Company with success particularly as regards to the short time required for operation. He stated that he believed that for differential protection a bushing type of transformer is as satisfactory as any other type. He pointed out that balanced current protection is distinctly faster than the impedance relay though the impedance relay has the advantage that after the first of two lines has been tripped out the other line is still protected. He agreed that the polyphase directional relay is quite satisfactory. He pointed out one particular scheme described in the paper in which three relays are used on a single line involving sixteen elements and seven auxiliary switches. He thought that this was a special case and that such complications are not usually desirable nor required. Mr. Crichton explained that the difficulty with bushing transformers of low ratio is that when several of them are in parallel and one of the lines is dead, the current from the other transformers will leak through the transformer on the dead line. This trouble has been prevented by placing auxiliary switches on the circuit breakers to cut out the dead transformer whenever the breaker opens, but this causes a bad spot in the wiring which has resulted in false operation of relays in some cases. He said that although the balanced relay is faster than the impedance relay, the difference in time is small compared to the time required for the circuit breakers to open. He agreed that the complicated scheme referred to by Mr. Traver is an unusual case and that such complication is not desirable.

In discussing the papers by Messrs. Lewis and Sporn, it was pointed out by V. M. Montsinger, W. L. Lloyd, Jr., and F. W. Peek, Jr., that the impulse ratio of transformer insulation is practically the same as that of disk insulators and that therefore the number of line insulators could be employed to determine the amount of transformer insulation using the 60-cycle test on both transformer insulation and insulators. This would obviate the necessity of trying to determine the impulse flashover value of transformer insulation. C. L. Fortescue drew attention to the fact that tests indicated that any surge due to lightning which goes slightly over the 60-cycle flashover value of the insulator string will cause a flashover. The quicker the flashover the less will be the severity of the surge impressed on connected apparatus, and for this reason, the arcing ring will decrease the severity of the effects of surges on connected apparatus because it flashes over more quickly under impulse voltages. J. F. Peters agreed that it is desirable to coordinate the insulation in a system but objected to Mr. Sporn's system of grading because he believes that the strongest link in the chain would be so heavily insulated that it would be too expensive. He suggested as a practical solution the establishment of one point in the chain which should be the weakest, with a sufficient margin between that point and the others to assure protection. That link, he said, should be either the line insulation adjacent to the station or a relief gap. He asked if ground wires will give the same ratio protection against direct lightning strokes as they do against induced strokes. In answering this question Mr. Peek said that he believed that proper ground wires will make a line almost lightning-proof against direct strokes as well as induced strokes. K. K. Palueff agreed that it is well to try to express the strength of all apparatus on a 60-cycle basis, but that we should not feel that when transformers can stand the 60-cycle test they will stand the same

impulse test as line insulators because the string of insulators is practically a condenser while the transformer is a combination of condenser and inductor and is subject to concentration of voltage in its different parts. J. F. Peters stated that in practise such concentration of voltage is not to be feared because all high-voltage transformers have a relatively high-capacity bushing which prevents an abrupt voltage being applied to the transformer. W. W. Lewis disagreed strongly with Mr. Peters contention stating that the transformer effect of the bushing is too small to do much good especially as the voltage wave which results from a flashover of line insulation is usually a very long wave.

Philip Sporn disagreed with the suggestions that transformer insulation should be gaged by the number of insulators. He contended that it is a step forward to actually determine the impulse strength of the various pieces of equipment. He disagreed with the contention that conditions at the present are good and that transformers are standing up well. He objected to Mr. Peters agreement that the highest link of the graded insulation would be so high as to be impractical or too expensive, stating that on one extensive system his company has been buying transformers considerably over-insulated (tested at three times normal voltage) and that this is believed to be a paying proposition.

M. A. Rusher inquired of Mr. Legg if the twin vibrator element described in his paper has more than one air gap and whether or not it has the same sensitivity and same natural frequency as the standard oscillograph. He asked also if the placing of fifteen records on one film prevents the distinguishing of one record from another. He mentioned that for a number of years he has used an oscillographic wattmeter which gives average power which is very easily read. In answering the first question Mr. Legg explained that the twin vibrator has an air gap over twice as large as the usual gap, but that the sensitivity is still twice that of the standard oscillograph. He explained that fifteen records could not always be made on one film but that if the driving speed of the film is great then the fifteen records can be very easily read. He pointed out that the fifteen records are in exact time-phase relationship. He said that in most cases the instantaneous wattmeter is preferable to the average-value wattmeter and that it occupies about the same space in the instrument.

Second Session—Miscellaneous Papers

1. *Selection of Railway Motor Equipment by Principles of Similar Speed-Time Curves*, B. A. Widell.
2. *Shunting of Track Circuit in Polyphase Continuous Inductive Train Control*, C. F. Estwick.
3. *The Diverter-Pole Generator*, E. D. Smith, Jr.
4. *Electric Conduction in Hard Rubber, Pyrex, Glass, Fused and Crystalline Quartz*, H. H. Race.

The discussion in this session centered on the paper by Professor Race. F. W. Grover stated that the specially interesting feature of this paper is that a supposedly homogeneous substance like fused quartz should show the effect of the absorbed charge. This effect has been observed for stratified dielectrics and some of the early investigators have claimed that homogeneous substances do not show the effect. A. S. Dana asked if the hard rubber investigated showed the same phenomenon as the fused quartz, namely, the reversal during the short period. In answering the last question Professor Race stated that his measurements were made after an interval of one minute and that only when in fused quartz something peculiar was noted during the first minute the apparatus was changed to make measurements during that earlier time; in the hard rubber no such effects appeared and, therefore, no measurements were made during the first minute.

Railroad and Railway Power

1. *Interconnection of Power and Railway Traction System by Means of Frequency Changers*, L. Encke.
2. *Application of Large Frequency Changers to Power Systems*, E. J. Burnham.
3. *Electrification on Illinois Central Railroad*, R. F. Schuchardt and W. M. Vandersluis.
4. *Mercury Arc Rectifier Substations*, G. E. Wood.
5. *Effect of Street Railway Mercury Arc Rectifiers on Communication Circuits*, C. J. Daly.

In discussing the first two papers, H. F. Brown explained why it had been thought desirable to connect one 25-cycle system to another 25-cycle system through a flexible variable-ratio frequency changer set. He enumerated five advantages which are: (1) The value of power interconnection, (2) The fact that a railroad load has a very ragged peak characteristic and this type of set eliminates the peaks from the smaller station, (3) A single-phase railroad load produces an underbalance between phases of a three-phase system and delivery of the load through this type of set eliminates the unbalance, (4) Such a load also has a poor power factor and by the use of such a set the power factor of a smaller system is not affected and the power factor of both systems may be improved, (5) The ability of the set to operate through heavy and frequent system disturbances.

O. E. Shirley pointed out that the choice of the type of regulating machine must be determined by the requirements of each particular case. P. W. Robinson stated that the efficiency of the Devon set at full load ranges from 90.08 to 89.22 per cent at operating conditions varying from no speed regulation to maximum regulation. He drew attention to the fact that the ordinary systems of exciting the regulating machine do not provide a means for building up and stablizing the voltage on the induction unit to supply power to a dead system but that special schemes for excitation may be provided to accomplish such results. A. G. Oehler asked if this type of set has equal ability to cushion shocks occurring on either end of the load.

E. J. Burnham answered this question in the affirmative. L. Encke pointed out that the efficiences in the paper are specified efficiencies and that the test efficiences are much higher—those at Station A being about the same as those at Devon.

In commenting on the paper by Schuchardt and Vandersluis, E. R. Hill stated that one of the most unusual features of the power contract is that specifying the supply of converted current at the seven substations located along the railroad. Another item to which he called attention as absolutely essential for railway electrification is that the power company must supply excess demands in railroad emergencies without affecting the demand charge. He mentioned another interesting contract consummated last year between the Pennsylvania Railroad and the Philadelphia Electric Company in which the outstanding feature is that the charges are based on actual cost to the power company of producing, transmitting and converting power. Some of the other main features of the contract pointed out by him are: (1) Demand determined monthly based on three maximum normal clock hours per month, (2) Demand may not be less than 75 per cent of any previous maximum demand, (3) Guaranteed monthly load factor is 30 per cent, (4) Guaranteed power factor is 55 per cent, (5) If lower rates are subsequently made to other consumers under similar conditions of supply, the railroad shall be entitled to the same rates.

At average montly load factor of 55.5 per cent, a coal cost of $5.00 per net ton, present labor rates and guaranteed maximum demand and energy costs, the average cost of energy to the railroad at the supply point or points under this contract works out 0.75 cents per kw-hr.

Sidney Withington pointed out that the question of power supply for railroad electrification is one not only of economy, but also of reliability and that it often happens that a compromise between these two is necessary. He explained that it may be more economical to develop a single central supply of power but that such a supply may necessitate installing transmission

facilities close to the tracks with consequent danger of interruption by derailment. As an alternative to a single supply there may be a central feed with supply points of relatively less capacity near each end of the electrified zone. Such an arrangement, while more expensive, is more reliable. A third possibility is a transmission network not adjacent to the right of way. Such a system may be fed from two or more independent power plants or interconnected with other systems. If conditions are favorable such an arrangement is from many points of view quite ideal for it allows advantage to be taken of the maximum railroad load factor with consequent minimum cost and with maximum reliability. The purchase of power by a railroad for traction purposes he said, other things being equal, should be more satisfactory than the operation by the railroad of its own plant. Such purchase eliminates the relatively large capital necessary for its own plant instalation. It is necessary he said that power companies consider all aspects of the question, such as diversity of load compared with other customers, volume of business, etc. It is logical to expect he said that the production of power by organizations specializing in such production would be more economical than production by the railroad itself providing that higher power plant efficiencies are not obtained at too high investment charges. It should be borne in mind also he pointed out that railroads can often purchase coal more advantageously than power companies and that railroads do not pay as high interest on capital as power companies. He emphasized that the power companies should be prepared to carry abnormal emergency loads without penalizing the road. G. I. Wright pointed out another advantage of electrification, namely, the possibility of stimulating off-peak business for the railroads. On communication lines, during the railroad rush hours, the revenue per passenger is less than during off-peak periods. After electrification improvement can be made in this condition by operating shorter trains and at more frequent intervals than would be possible with steam operation. H. C. Sutton pointed out a factor which should be very interesting to the power companies, namely, that with the extension of electrification to trunk-line railroads the power factor will be greatly improved possibly going to 65 per cent instead of 26 to 30 per cent which prevails for suburban service. He pointed out that railroads should benefit by purchasing power on account of the fact that power plants become relatively uneconomical within a ten year period. Power companies on account of their continued expansion are continually building better power plants with resulting higher efficiency and the railroads should benefit by readjustments in cost of power which they would not do if they owned their own plants. O. K. Marti asked if it would be feasible to use a higher voltage on the trolley line, pointing out the increased efficiency which would result from 1500 to 3000 volts especially when mercury arc rectifiers are employed. He asked also if a higher voltage drop can be allowed on the trolley wires as this would be more economical. P. H. Hatch suggested that consideration be given to independently propelled locomotives such as Diesel-electric and straight Diesel engines. He asked if there is any movement towards standardizing the alternating current supply for railroads at either 25 cycles or 60 cycles.

In discussing Mr. Daley's paper P. W. Blye stated that the most interference with communication circuits is to be expected from individual stub-end feeders and that the most serious effects have been noticed in the case of interoffice trunk circuits, party-line subscribers circuits and private-branch exchange systems. He indicated that tuned filters have been effective in suppressing interference in the ratio of about ten to one. R. G. McCurdy and J. W. Millnor brought out that interference was to be expected from the alternating-current feeders as well as the direct-current and C. I. Hall contended that the interference from alternating-current feeders would be even more than that from the direct-current feeders. O. K. Marti pointed out that if part of the load is supplied from rotating machinery, interference will not be as great as if the entire load is supplied by rectifiers. In case of harmonics on the a-c. circuits he thought that these can be absorbed by transformers.

POWER DEVELOPMENTS

1. *The Mercury Boiler and Turbine*, L. A. Sheldon.
2. *The Rocky River Development of the Connecticut Light and Power Co.*, E. J. Amberg.

In discussing the second paper in this session J. B. Justin stated that in Europe 35 or 40 plants have been built along lines similar to the Rocky River Development. He said that he believed there will be a good many more such plants in America because there is an economic application for plants of this kind. In answering a question of P. M. Lincoln, E. J. Amberg stated that the figures for run-off include the net run-off after evaporation has been subtracted. He pointed out another advantage of the Rocky River scheme, namely, that the plant is instantly available in case of a break down of another unit on the system. To have this emergency feature in a steam plant it is necessary to keep additional boilers fired and even then the emergency turbine cannot be put on the system as quickly as can the hydroelectric unit.

A. I. E. E. Directors' Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Friday, May 18, 1928.

There were present: President Bancroft Gherardi, New York, N. Y. Vice-Presidents G. L. Knight, Brooklyn, N. Y., J. L. Beaver, Bethlehem, Pa.; A. B. Cooper, Toronto, Ont.; Managers H. A. Kidder, New York, N. Y.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; National Secretary F. L. N. Y. Hutchinson, New York.

The minutes of the Directors' meeting of April 6, 1928, were approved.

Approval was given to the report of the meeting of the Board of Examiners held May 16; and upon the recommendation of the Board of Examiners the following actions were taken: 164 Students were enrolled; 131 applicants were elected to the grade of Associate; 11 applicants were elected to the grade of Member; two applicants were transferred to the grade of Member; one applicant was transferred to the grade of Fellow.

The Board ratified approval by the Finance Committee for payment, of monthly bills amounting to $32,577.03.

The Secretary reported 1594 members in arrears for dues for the fiscal year ending April 30, 1928 (nine Fellows, 114 Members, 1471 Associates), and was directed to remove the names of these members from the mailing list and place them upon a "suspended" list, and to employ the usual methods of collecting the dues and restoring the members to the active membership list.

Upon application and in accordance with Section 22 of the constitution, the following members were made "Members for Life" by exemption from future payment of dues: Messrs. R. N. Baylis, F. Bourne, E. Caldwell, C. L. Cory, A. H. Cowles, O. G. Dodge, W. G. Ely, C. M. Goddard, W. E. Goldsborough, E. M. Hewlett, H. Howson, R. M. Hunter, H. Lemp, H. V. A. Parsell, F. A. Pattison, M. I. Pupin, J. Sachs, A. J. Wurts.

Upon the recommendations of the Sections Committee and the Committee on Student Branches, authorization was given for the organization of an Institute Section at Dallas, Texas, and a Student Branch at the University of Detroit.

The annual report of the Board of Directors to the membership, as prepared under the direction of the National Secretary, was considered and approved for presentation at the Annual Meeting of the Institute, on June 26.

The annual reports of the general standing committees of the Institute (exclusive of the reports of the technical committees, which will be presented at the Annual Summer Convention in June) were presented and ordered filed for future reference. Abstracts of these reports were incorporated in the Board of Directors' annual report.

In accordance with Section 37 of the constitution, the appointment of a National Secretary for the administrative year beginning August 1, 1928, was considered, and National Secretary F. L. Hutchinson was reappointed.

Upon the recommendation of the Standards Committee, Standards for Measurement of Test Voltages in Dielectric Tests (No. 4) were approved as A. I. E. E. Standard; and it was voted to request the discharge by the American Engineering Standards Committee of the Sectional Committee for Standards on Electrical Installations on Shipboard. The recommendation of the Standards Committee was also adopted to appoint Dr. A. E. Kennelly to represent the Institute at a proposed American conference on Electrical Units.

Upon the recommendation of the Committee on Safety Codes, the Board adopted a resolution approving the Standard Rules for the application of the Prone Pressure Method of Resuscitation, which have been prepared for universal adoption in this country under the auspices of the United States Public Health Service, and which have been approved by various organizations. The Safety Codes Committee was authorized to keep in contact with the plans of the National Safety Council in connection with the Annual Safety Congress to be held in New York City next October, and the Secretary was authorized to arrange for publication in the Journal, of announcements of the Congress and information regarding its program.

An invitation to the Institute to participate in the Tenth Annual Meeting of the Army Ordnance Association, at Aberdeen Proving Ground, October 4, 1928, was accepted, and the Secretary was authorized to publish information concerning the meeting in the Journal.

An inscribed photograph of Sir Oliver Lodge, presented to the Institute by Sir Oliver through President Gherardi as a memorial to the joint transatlantic meeting of the British Institution of Electrical Engineers and the A. I. E. E., last February, was accepted by the Board and a resolution of appreciation was adopted.

Other matters of importance were discussed, reference to which may be found in this and future issues of the Journal.

Second National Fuels Meeting

The Second National Fuels Meeting, under the auspices of the Fuels Division of The American Society of Mechanical Engineers, will be held in Cleveland Sept. 17-20, 1928.

For years, central station engineers have realized the importance of fuel problems, studying them individually and collectively. A very interesting and instructive technical program is being prepared to cover a wide variety of subjects, such as solid, liquid, and gaseous fuels in all fields. A dinner, buffet luncheon, and smoker and other forms of entertainment, as well as a number of plant inspection trips, are being planned. Complete program will be available later.

Lincoln Arc Welding Contest Prizes Awarded at Spring Meeting of A. S. M. E.

Before formal award was made Mr. J. C. Lincoln briefly outlined the purpose of this contest.

Seventeen thousand five hundred dollars, donated by The Lincoln Electric Company, Cleveland, Ohio, has been distributed in the Lincoln Arc Welding contest as follows:

James W. Owens, director of welding for the Newport News Shipbuilding and Drydock Company at Newport News, Va., won the first prize of $10,000 awarded in the arc welding contest. Mr. Owens a Fellow of the Institute, is a past Vice President of the American Welding Society. He is also author of the text book "Fundamentals of Welding."

Five thousand dollars, the award for the second best paper submitted was won by Henri Dustin, Professor in the Engineering School of the University of Brussels, Belgium and Director of the Laboratory for Material Testing. Third place award $2500 was given to Commander H. E. Rossell, Construction Corps, United States Navy, instructor of mathematics at the U. S. Naval Academy at Annapolis. Honorable mention was given to the papers submitted by Frank B. Walker, Winthrop, Mass., and B. K. Smith, President of the Big Three Welding and Equipment Company, Houston, Texas.

Edison Receives Medal From Society of Arts and Sciences

The Society of Arts and Sciences announces the award of its Gold Medal for Science to Thomas Alva Edison for distinctive achievement in science, the presentation ceremonies to take place at the Hotel Astor, on the evening of May 24. Dr. John C. Merriam, president of the Carnegie Institution of Washington and Dr. Elihu Thomson, director of the Thomson Laboratories of the General Electric Co., will be the principal speakers.

Lamme Foundation Award Established

At Ohio State University this spring a gold medal will be awarded for the first time by the Lamme Foundation, established by Benjamin Garver Lamme, an alumnus of the class of '88. The medal, which contains $100 worth of gold, is to be awarded every five years to a graduate in any branch of engineering at Ohio State.

On one side of the medal appears a male figure representing electric power in the act of reaching to the clouds for electrical energy with one arm and with the other supplying this energy to the world; on the other side is reproduced a bas-relief of Mr. Lamme, with the dates 1864 to 1924 and the quotation for which Mr. Lamme became noted: "The engineer views hopefully the hitherto unattainable."

Mr. Lamme, himself, received, the Edison medal and the Sullivant medal awarded five years ago for the first time at Ohio State University.

The American Museum of Safety Medal Awards

Arthur Williams, vice-president of the New York Edison Company announced, as president of the American Museum of Safety, that the Anthony N. Brady Memorial Medals would be awarded to electric street railways for safety and sanitation work for the year ended December 31, 1927 and that definite decision on conditions covering the contest for 1927 would be reached at an early date, probably early in June. The awards will be made jointly by the American Railway Association and the American Museum of Safety. The winners for 1926, to which medals were presented at ceremonies in New York City last January, were the Louisville (Kentucky) Railway Company, The El Paso (Texas) Electric Company and The Tide Water Power Company of Wilmington, North Carolina, with the Pittsburgh Railways Company receiving honorable mention.

ENGINEERING FOUNDATION

ENDOWMENT COMMITTEE SEEKS INCREASED FUNDS

Engineering Foundation, organized 13 years ago through the generous initial gift of Ambrose Swasey of Cleveland and sustained and expanded by the subsequent gifts of Henry R. Towne, Edward Dean Adams and others through its Endowment Committee has announced its intention of securing a fund of five million dollars to expand its program better to meet the needs of industry. In its work, Engineering Foundation has not been unmindful of the human element in modern engineering, aiding to establish the Personnel Research Federation, assisting the endeavors of the Society for the Promotion of Engi-

neering Education and the engineering profession and industry in general. Members of the Committee are Col. Edward A. Simmons, chairman, Hon. Herbert Hoover, R. V. Wright, E. B. Craft, L. B. Stillwell, C. F. Loweth, H. deB. Parsons, R. J. Reed, Thos. B. Stearns, J. V. N. Dorr, T. Robins, J. W. Lieb, W. Meredith, H. A. Lardner, E. W. Rice, Jr., Calvert Townley, E. G. Acheson, J. H. Hammond, H. H. Porter, W. L. Saunders, E. A. Sperry and Alfred D. Flinn.

American Engineering Standards Committee

WILLIAM J. SERRILL TO HEAD INDUSTRIAL STANDARDIZATION MOVEMENT.

Announcement is made of the election of W. J. Serrill, assistant general manager of the United Gas Improvement Company of Philadelphia to succeed C. E. Skinner as chairman of the Standards Committee. Mr. Skinner has served the committee for the past three years, during which time the national standardization work has doubled in volume. The executive committee to serve under Mr. Serrill is a large one of broad representation, including the American Institute of Architects, the U. S. Department of Commerce, the American Railway Association, the American Mining Congress, the Panama Canal, U. S. Departments of the Interior, Agriculture, Labor, War, the Navy Department, the American Society for Testing Materials, a Telephone Group, Fire Protection group, Safety group, Society of Automotive Engineers, several industrial interests, The American Institution of Mechanical Engineers and the four National Engineering Societies, Civil, Mechanical, Mining, and Electrical Engineers Societies.

A. T. and T. and Western Electric Arrange for Talking Motion Pictures

Contracts have been entered into by Paramount, Metro-Goldwyn and United Artists motion picture producers for the use of the Western Electric System for talking pictures. Simultaneously the Electrical Research Products, Inc., entered a contract which grants the motion picture companies licenses under the patents of the American Telephone & Telegraph Co. and Western Electric Company for talking motion pictures.

Years of experiment lie back of the talking pictures. In the last analysis, they are a by-product of the telephone, for it was through the continued study of Bell Laboratories experts of the ways in which speech is produced that they were ultimately developed. Successive steps in this development were the perfection of the public address system for amplifying and distributing sound; the development of electrical methods of recording sound on phonograph records as now successfully employed by the Victor and Columbia phonograph companies; and the recording and reproduction of sound in conjunction with motion picture film, now in use for more than a year in movietone and vitaphone productions.

It is understood that more than 300 theaters are equipped now for the showing of vitaphone and movietone, while orders for 300 additional theaters have recently been placed and call for installation within the next three or four months. With the impetus which the signing of the new contracts will bring, it is conservatively estimated that by the end of 1928 at least 1000 theaters will be so equipped.

Louvain Carillion "Christened"

On the 18th May the memorial carillon of forty-eight bells, the gift of American Engineers to the Louvain Library, was played for the first time in the works of the makers, Gillett & Johnston, Croydon, England. Day and night the work has been pushed to have the bells ready for dedication in the library tower on the 4th of July.

For a working test and "christening", the carillon has been set up in the shops. Mr. Josef Denyn, the world-famous carilloneur of Malines, Belgium, who will play the carillon at the dedication of the library, was invited to Croydon to participate in the tests. On the 18th the bells were played for the first time by Mr. Denyn in the presence of the King and Queen of the Belgians, the Ambassadors to England from Belgium and the United States, the American Society in London, the Anglo-Belgian Union, and other notable guests.

Shipment to Belgium and installation in the Louvain Library Tower of the carillon and the memorial clock, with its dial represented by 48 stars instead of the customary numerals, will begin at once. A large group of members and friends of the engineering societies of the United States will be in Louvain on July 4th to assist in the dedication of their memorial to the engineers of our country who gave their lives in the World War.

AMERICAN ENGINEERING COUNCIL

ACTIONS OF ADMINISTRATIVE BOARD

At its recent meeting in Milwaukee, the Administrative Board of the American Engineering Council, endorsed the creation of a commission of engineers as proposed in the Douglas Bill to investigate the physical problems connected with flood control and development of the Colorado River. The program contemplated by the Douglas Bill was approved "subject to the report of the aforesaid commission of present expenditures on the Colorado River confined only to flood protection."

The report of the Council's Committee on Street Signs, Signals, and Markings was adopted, and the executive secretary was authorized to proceed with publication. The personnel of the Committee was enlarged to comply with the regulations necessary to qualify as a Sectional Committee of the American Engineering Standards Committee.

Arthur W. Berresford, president of the Council, reported to the Board the Council's activity in the Mississippi flood legislation, and presented the report of the Committee on Boulder Dam, (headed by Francis Lee Stuart of New York), which unanimously decided against the engineering feasibility of the proposal outlined in the Swing-Johnson Bill.

President Berresford told also of the progress of the movement to transfer to the Department of the Interior the public works functions of the Government. The Council has been energetically supporting the public works measure known as the Wyant Bill. Hearings on this Bill were held before a subcommittee of the Committee on Expenditures in the Executive Departments of the House in April. Among those who appeared in behalf of the Council to urge the enactment of the measure into law were President Berresford, Gardner S. Williams, E. O. Griffenhagen, and Farley Osgood.

"Practically every Government Bureau and Department affected," President Berresford stated, "is opposed to the passage of this legislation, the Engineer Corps bitterly fighting it, followed in almost the same degree, by the Bureau of Public Roads. It is not expected that the Bill will be reported this session."

The Council voted not to participate in the World Congress of Engineers on the ground that the Congress is beyond its scope. For the same reason the Council declined to take part in an effort to make the American Committee of the World Power Conference a permanent organization.

The Executive Committee endorsed the Browne Bill, introduced in the House, and providing for "the conduct of scientific investigations by the Forest Service to discover economically practical methods of the disposal of the waste materials of pulp and paper mills without polluting streams."

The Executive Committee reaffirmed its oppositon to the Senate Bill providing for the extension of the time limitations under which patents were issued in the case of persons who

served in the military or naval forces of the United States during the World War.

The Administrative Board approved the reports of the president, the executive secretary, and the treasurer of the Council.

The president's Committee on Constitution, By-Laws and Activities of the American Engineering Council submitted several proposed changes to the constitution, by-laws, and standing rules which are to be presented to the Assembly of the Council.

Resignation from the Administrative Board of E. S. Lanphier of New Orleans, representative of the Louisiana Engineering Society, was announced. A. A. Krieger automatically becomes a member of the Board.

Newton's Principia

Through the generosity of Dr. Edward Dean Adams, the Engineering Societies Library has acquired recently a copy of the first edition of Newton's "PRINCIPIA." The volume, a large quarto in a contemporary English calf binding, is in unusually fine condition.

First editions of this famous book are exceedingly rare. Only a small number of copies was printed and because of the importance of the work, these were rapidly distributed. In 1691, four years after publication, a copy could scarcely be procured.

The "Philosophiae Naturalis Principia Mathematica" was published in London in 1687. The Royal Society published it, but as the Society was financially embarrassed at the time, the expense of publication was actually borne by the astronomer, Edmund Halley, who had first brought it to the attention of the Society. It fell to the fate of Samuel Pepys, then president of the Royal Society, to give it the "Imprimature."

The "Principia" is probably the most important book on exact science ever written, and certainly is one of the most consistently original. It formulated the fundamental laws of mechanics for the first time, and the mathematical ideas required in the arguments were invented by its author. It explained phenomena which had never before been explained satisfactorily, and initiated problems that still occupy the minds of our best thinkers.

The Library has also an edition of the "Principia" published at Glasgow in 1822. This is a reissue of the so-called "Jesuits' edition" and is valued for the copious commentary and notes.

Of Newton's works, only one complete edition has appeared, published in 1779-1785 in five volumes. A copy of this is in the Library also.

Summer School for Engineering Teachers

The Society for the Promotion of Engineering Education has completed plans for the two sessions of the summer school for engineering teachers to be held during 1928, summarized as follows: One session for physics and the other electrical engineering:

The electrical engineering session, to be held at Pittsburgh under the joint auspices of the University of Pittsburgh and the Westinghouse Electric and Manufacturing Company, will open on Thursday, July 5, and close on Wednesday, July 25; physics, at the Massachusetts Institute of Technology in Cambridge, to open Monday, July 9, and close on Saturday, July 28.

A complete program of the electrical engineering session will be found in the April issue of the *Journal of Engineering Education.* About two-thirds of the meetings will be devoted to methods of teaching and will be held at the University of Pittsburgh. Among the topics to be considered are: the learning process; the teaching process; the fundamentals of electrical engineering study and methods of teaching them; the analysis of various teaching processes; laboratory work; the history of electrical science and of electrical units; the methods of teaching various divisions of electrical engineering; application courses; communication courses; courses for students other than electrical engineers, etc.

The program is being arranged in cooperation with the American Physical Society, through an advisory committee consisting of W. L. Severinghaus, Columbia University, chairman; A. W. Duff, Worcester Polytechnic Institute; O. M. Stewart, University of Missouri; P. I. Wold, Union College; and John Zeleny, Yale University.

Tuition charges will be limited to a registration fee of $10, and applications for admission should be addressed to H. P. Hammond, Associate Director of Investigation, S. P. E. E., 33 West 39th Street, New York, N. Y.

Society of American Military Engineers Extends Welcome

The Society of American Military Engineers invites members of the Institute who may be in Washington at any time to make use of its national headquarters and to attend meetings of the Society.

PERSONAL MENTION

THEODORE BERAN, commercial vice-president of the General Electric, in charge of the New York District, has retired, effective May 1. Until his election as vice-president in 1926, Mr. Beran had been manager of the district since 1903.

E. A. SPERRY, chairman of the Board of Directors of the Sperry Gyroscope Co., Brooklyn, N. Y., has been chosen as presidential candidate by The American Society of Mechanical Engineers.

O. R. BAILLY, has made a change from the Testing Department of the General Electric Company at Schenectady and Pittsfield Works to foreign work in South American properties of the Electric Bond & Share Company.

ELMER A. SMITH was recently signally honored by the Academies of Var and Nevers, France, the University of Durham, England and the Royal Society of Rumania in recognition of distinguished service rendered to electrical engineering and physics.

C. W. STONE, manager of the General Electric Central Station Department, has been appointed to the position of consulting engineer, and M. O. TROY now becomes manager of the Central Station Department as announced by Gerard Swope president of that company.

LOYALL A. OSBORNE, president of the Westinghouse Electric International Company, was reelected chairman of the National Industrial Conference Board at its twelfth annual meeting held May 18 at the Hotel Astor. In this work he will be closely associated with Magnus W. Alexander, president of the Board.

C. P. POTTER, engineer in charge of the Large Motor and Transformer Divisions of the Wagner Electric Corporation, St. Louis, Mo., has been elected chairman of the St. Louis Section of the A. I. E. E., in recognition of his activity in the organization for many years. He has already served on many of its committees and last year was vice-chairman of the section.

JOHN MURPHY has been made president of the Ottawa Rotary Club, of which he was always, a very popular member. Mr. Murphy who has been a member of the Institute since 1900 and a Fellow since 1913, is past president of Ottawa branch of the Engineering Institute and an officer of most of the Canadian and American electrical commissions and associations.

A. L. JONES, assistant district manager for the General Electric Co. in the Rocky Mountain region, has been appointed to succeed the late Robert Miller, as district manager. General Offices for the Rocky Mountain District, which includes parts of nine states, are at Denver, with sub-offices at Butte, Mont. and Salt Lake City. This is the territory in which the General Electric Co. operates KOA.

L. A. Zima has joined the staff of the Rome Wire Company, Division of General Cable Corporation, as district engineer in the New York office. Mr. Zima was formerly cable engineer with Brooklyn Edison Company in charge of design and specification of cables for power stations, substations, and transmission and distribution systems. During his connection with Brooklyn Edison, he spent three months in Europe, visiting cable manufacturers and utilities in England and the continent, studying cables and cable systems. Mr. Zima is a member of the Underground System Committees of the Metropolitan and National Sections of N. E. L. A. and also of the Empire State Gas & Electric Association. He joined the Institute in 1915.

Professor Franz A. Kartak, head of the department of electrical engineering at Marquette University, has recently been appointed dean of the College of Engineering at that university, and will take office after the close of the present semester. Professor Kartak was graduated from the University of Wisconsin with the degree of B. S. in electrical engineering in 1909, and was awarded the degree of E. E. in 1911. After four years in the Department of Electrical Engineering of the University of Wisconsin as research assistant and instructor, he was in 1913 appointed director of the newly created standards laboratory, but continued teaching courses in electrical testing, illumination, and photometry. In addition to his university work, he was a member of the engineering department of the Railroad Commission of Wisconsin, beginning in 1913, and in 1916 became a member of the Wisconsin state staff of engineers. He went to the School of Engineering of Milwaukee as professor of Electrical Engineering in 1919, and remained until 1921, when he accepted the position he now holds. Professor Kartak joined the Institute in 1910, and was transferred to the grade of Member in 1920.

Obituary

Charles Sumner Winston, of 9 Paddington Road, Scarsdale, N. Y., died March 20. Mr. Winston was a native of Forreston, Illinois. He was graduated from the University of Chicago in 1896 with the degree of A. B., and took work in electrical engineering at the University of Illinois during the college year 1897-1898. In June 1898 he entered the employ of the Western Electric Company at Chicago, and for six months worked in the Switchboard and Installation Departments of the company. He was then transferred to the Engineering Department, where he remained for the balance of his stay with the company, or until 1901, when he accepted a position with the Engineering Department of the Kellogg Switchboard & Supply Company, Chicago. On January 1, 1904, Mr. Winston was placed in charge of the entire work of the department, and shortly thereafter became chief engineer. He came to New York and was chosen president of the Cornell Utilities Co., which was his position at the time of his death. Mr. Winston joined the Institute in 1906.

John Joseph Murphy, president and engineer of the Electric Construction & Machinery Company, Rock Island, Illinois, passed away April 4. Mr. Murphy was born March 27, 1869 at Rock Island, and his education was acquired in an academic course at St. Joseph's School, supplemented by such practical information as came to him through thirty years of business and the development of technical papers. In July 1896 he joined the Iowa Bell Telephone Company as groundman and lineman, remaining with it until January 1897. From 1898 to 1912 he was in charge of all construction work in the plant as well as outside work for the Peoples Power Company's Illinois territory, after which he served the Electrical Construction and Machinery Company for many years as construction engineer manifesting no small ability to accomplish. Mr. Murphy was a member of the American Military Engineers and in June 1917 was commissioned an officer in the Engineers Corps. In all of his work, Mr. Murphy was considered a man of ability and execution. He became an Associate of the Institute in 1910 and was transferred to the grade of Member in 1925.

Paul T. Brady, associated with the Westinghouse Electric & Manufacturing Company for 34 years, died of sudden heart failure at the age of 71 at the home of his son, Portland, Oregon, May 3. He was born in Cooperstown, N. Y., attended the Exeter Academy, teaching school himself for several years after his graduation. In 1881 he joined the American Telephone and Telegraph Company and was instrumental in extending the telephone system through the southeastern portion of New York State, at the same time organizing and building some of the first electric light plants in this district. In 1890 he joined the Thomson-Houston organization, which later became a part of the General Electric Company; here he was manager of that company's affairs in New York State and the Middle West. In 1894 he became New York State manager for the Westinghouse Electric & Manufacturing Company with headquarters in Syracuse. In 1907 he was transferred to the New York office as the Company's special representative which was his position at the time of his death. Mr. Brady was one of the pioneers of the electric light and power industry, combining technical electrical knowledge with financial ability and insight. He has left behind him as a monument more than a score of successful electrical systems which he brought into being. He joined the Institute in 1887 and for the past year has been a Member for Life.

Kyojiro Yosugi, electrical engineer to the Yokohama Electric Wire Works of the Furukawa Electric Co., Ltd., Nishi-Hiranuma Yokohama, Japan, died February 17, 1928. Mr. Yosugi was a graduate from the Electrical Engineering Department of the Tokio Imperial University in 1919, and immediately thereafter entered the Testing Department of the Yokohama Electric Wire Works, where he advanced to manager. In 1921 he became production manager of the Rubber Insulated Wire and Cable Shop of the same company, then manager of the Electrical Department and ultimately manager of the design department. Mr. Yosugi was elected to membership in the Institute in 1924.

V. Frank Buddeke, assistant engineer of the Public Service Company of Northern Illinois, Chicago, died March 4, 1928. Mr. Buddeke was born in Cincinnati, April 23, 1901, and there attended grammar and high school, following it with four years at the University of Illinois, where he went through the School of Engineering. For one summer vacation, he worked with the Commonwealth Edison Company in station construction work and was graduated June 1924. After graduation, he returned to this company, entering the Engineering Distribution Dept. Thence he entered the Distribution and Transmission Engineering Dept. of the Public Service Company of Northern Illinois where he remained until his death. Mr. Buddeke had been an Associate of the Institute for one year.

District Prizes Awarded

Prizes for papers presented during 1927 have been awarded by five Geographical Districts of the Institute. The winners of the prizes with the titles of their papers are shown below. A certificate of award has been given to each winner and a cash prize of $25 was given for each paper, the cash prize being divided equally among the authors of papers written jointly by two or more persons.

These awards were made by the respective prize committees of the Districts according to the Institute's rules on prizes.

DISTRICT NO. 1.

Best Paper Prize and Initial Paper Prize: H. S. Litchfield, for his paper *The Most Economical Power Factor*, presented at the Pittsfield Regional Meeting, May 25-28, 1927.

Branch Paper Prize: G. H. Rockwood, for his paper *Calculation of Stray Load Losses*, presented at the Student Session of the Pittsfield Regional Meeting, May 25-28, 1927.

DISTRICT NO. 2.

Best Paper Prize and Initial Paper Prize: S. K. Waldorf, for his paper *An Amplifier to Adapt the Oscillograph to Low-Current Investigations*, presented at the Meeting of the Baltimore section, April 22, 1927.

DISTRICT NO. 5.

Branch Paper Prize: John A. Sargent, for his paper *The Location of Faults on Parkway Cable*, presented at the Student Session of the Chicago Regional Meeting, November 28, 1927.

DISTRICT NO. 9.

Best Paper Prize and Initial Paper Prize: Ray Rader, for his paper *A Discussion of Short-Circuit Problems and the Application of the Testing Board in Their Solution*, presented at the meeting of the Seattle Section, May 17, 1927.

Branch Paper Prize: F. D. Crowther and R. L. Earnheart, for their paper *Alternating-Current Transients in Incandescent Lamps*, presented at the Joint Meeting of the Portland Sections, A. I. E. E. and N. E. L. A. and Oregon State College Branch, May 7, 1927.

DISTRICT NO. 10.

Best Paper Prize: W. P. Dobson, for his paper *The Electric Strength of Solid Insulation*, presented at the meeting of the Toronto Section, November 25, 1927.

Initial Paper Prize: George D. Floyd, for his paper *Technical and Economic Analysis of Electric Power Transmission*, presented at the meeting of the Toronto Section, January 14, 1927.

A. I. E. E. Section Activities

Future Section Meetings

Sharon

Banquet Meeting. *The Psychology of Laughter*, by Charles Milton Newcomb. June 5.

Vancouver

Annual Meeting and Dinner. June 5.

SECTION MEETINGS

Akron

Transatlantic Telephony, by Dr. Dirk Schregardus, Ohio Bell Telephone Co. Illustrated with slides and motion pictures. Dinner preceded the meeting. October 7. Attendance 25.

Electric Welding, by H. G. Bissel, Westinghouse Electric & Mfg. Co., and D. H. Deyoe, General Electric Co. Illustrated. Preceded by dinner. November 11. Attendance 46.

Load Dispatching in a Large Interconnected System, by T. J. Williams, Ohio Power Co. Preceded by dinner. December 9. Attendance 34.

Automatic and Supervisory Control of Railway Substations, by L. D. Bale, Cleveland Railway Co. Inspection trip. January 14. Attendance 45.

Vertical Transportation, by L. A. Petersen, The Otis Elevator Co. Illustrated by slides. Preceded by a dinner. February 10. Attendance 23.

Necessary Characteristics of High-Voltage Insulators as Determined by Line Conditions, by A. O. Austin, The Ohio Insulator Co. Illustrated. Preceded by a dinner. March 23. Attendance 100.

The Commercial Development of Lighter-Than-Air Air Craft, by Dr. Karl Arnstein, Goodyear Zeppelin Corp. Illustrated. Preceded by a dinner. April 6. Attendance 150.

Baltimore

Development of Transportation as Typified in the 100 Years' History of the Baltimore and Ohio Railroad, by O. C. Cromwell, B. & O. R. R. A dinner preceded the meeting. September 28. Attendance 85.

Some Problems of Telephony, by H. S. Osborne, American Tel. & Tel. Co. A dinner preceded the meeting. October 8. Attendance 130.

Aviation, by Dr. G. W. Lewis, National Advisory Committee for Aeronautics, and Major W. D. Tipton, Maryland National Guard. Dinner preceded the meeting. November 18. Attendance 85.

The Modern Oscillograph—Analyst of the Unknown, by J. W. Legg, Westinghouse Electric & Mfg. Co. December 16. Attendance 60.

Symposium of European Engineering Practise, by Dr. J. B. Whitehead, Johns Hopkins University, and H. R. Cook, Consolidated Gas, Electric Light & Power Co. A dinner preceded the meeting. January 19. Attendance 85.

Heating and Uses of Electricity in Office Buildings, Hotels, Stores, etc., by J. Posey and M. N. Oates, Consolidated Gas, Electric Light & Power Co. Joint with A. S. M. E. February 23. Attendance 90.

Boston

Desirable and Reasonable Traffic Regulations, by E. W. James, Bureau of Public Roads. Joint meeting. April 18. Attendance 150.

Financial, Engineering and Construction Problems of a Large Project, by H. A. Hageman and W. L. Locke, Stone and Webster, Inc., and R. H. Barclay and C. W. Kellogg, Public Service Company. Joint meeting with Massachusetts Institute of Technology Branch. April 27. Attendance 260.

Cincinnati

Low-Voltage A-C. Network System in Cincinnati, by Lester Bosch and Charles Thomas, Union Gas and Electric Co. Illustrated. April 12. Attendance 85.

Mitigation of Acoustic Shock and Hazard in Telephone Communication. Joint meeting with University of Cincinnati Branch. May 10. Attendance 51.

Cleveland

Interconnection of Power Systems, by Philip Sporn, American Gas and Electric Co. Illustrated. April 19. Attendance 80.

Columbus

The Televox, by R. J. Wensley, Westinghouse Electric & Mfg. Co., Joint meeting with Affiliated Technical Societies of Columbus. March 16. Attendance 1000.

Arc Welding—Present and Future, by R. P. Tarbell and H. T. Egan, Lincoln Electric Co. A dinner preceded the meeting. March 23. Attendance 61.

Connecticut

Applied Electrochemistry, by Dr. C. G. Fink, Columbia University, and

System Planning, by L. W. W. Morrow, Managing Editor, *Electrical World*. January 24. Attendance 100.

Aviation Today in Peace and War, by Lieut. B. G. Leighton, Commander, U. S. Navy. April 17. Attendance 40.

Denver

Industrial Development and Distribution, by F. E. Shepard, Superintendent, Denver Mint. October 4. Attendance 50.

The Romance of Power, by C. M. Ripley, General Electric Co. October 18. Attendance 75.

Some Phases of Utility Financing, by J. E. Loiseau, Secretary, Public Service Co. of Colorado. January 17. Attendance 40.

The Romance of Broadcasting, by F. H. Talbot, Director, KOA Broadcasting Station. April 3. Attendance 45.

Dinner. April 10. Attendance 109.

Methods of Construction at Conowingo, by G. P. Jessup, Stone and Webster, Inc. Illustrated. Preceded by a dinner. April 20. Attendance 50.

Present Status of Mercury Boiler and Turbine, by P. B. Coulson, General Electric Co. Illustrated. May 9. Attendance 55.

Application of the Photoelectric Cell to Measurements of Light Intensity, by G. K. Baker, L. L. Booth and R. G. Hays, University of Denver;

Magnetic Properties of Iron, by Edwin Whitehead, University of Colorado;

Electric Power in the Modern Cement Plant, by H. P. Groat, Colorado Agricultural College, and

Phase Advancer for Induction Motors, by R. A. Shields, University of Colorado. Annual College Branch Night. Preceded by a dinner. May 11. Attendance 94.

Detroit-Ann Arbor

Precise Metering, by B. W. St. Clair, General Electric Co. Illustrated. A dinner preceded the meeting. April 17. Attendance 105.

Erie

Measurement of Surge Voltages on Transmission Lines, by C. M. Foust, General Electric Co. Illustrated. April 17. Attendance 50.

Fort Wayne

The Finest Motive Power in the World, by Alan Rogers, Supervisor of Public Relations, New York Central Lines. March 29. Attendance 50.

Indinapolis-Lafayette

Public Utilities and Their Relation to the Consumer, by C. F. Hirschfeld, Detroit Edison Co. Joint dinner meeting with A. S. M. E. April 20. Attendance 68.

Ithaca

Aims and Activities of the American Engineering Council, by A. W. Berresford, President, American Engineering Council;

The Economics of Power Distribution, by Alex Dow, President, A. S. M. E., and

Transatlantic Radio Telephony, by Bancroft Gherardi, National President, A. I. E. E. Annual Engineering Banquet. March 16. Attendance 250.

Alternator Oscillograph Studies, by S. R. Knapp and J. R. Burnell;

Water Levels of Cayuga Lake, by D. J. C. Werner;

Polarization and Absorption in Dielectrics, by E. J. Atkins, Jr., and

Electric Locomotive Construction, by D. W. Exner. Student meeting. April 13. Attendance 70.

The Use of Pyrex Insulators on High-Voltage Transmission Lines, by Dr. J. T. Littleton, Corning Glass Works, and

Oil Puncture Tests on Insulators, by W. W. Shaver, Corning Glass Works. An inspection trip to the Corning Glass Works preceded the talks. April 28. Attendance 102.

Historical Development of A. I. E. E. Sections, by P. M. Lincoln, Cornell University, and

A New Industrial Day, by Dean D. S. Kimball, Cornell University. May 3. Attendance 135.

Kansas City

River Navigation and Terminal Facilities, by A. W. Mackie, Construction Equipment Co. Joint with A. S. M. E. March 26. Attendance 55.

Research and the Public, by L. A. Hawkins, General Electric Co. April 17. Attendance 110.

Lehigh Valley

The Use of Electricity in an Automotive Vehicle, by L. C. Josephs and C. A. Froesch, International Motor Co. Dinner preceded the meeting. February 18. Attendance 36.

Cost Accounting for Engineers, by J. F. W. Heinbokel, C. P. A. and G. E. Dignan, Rust Engineering Co. Inspection trip to Scranton Lace Co. Dinner. Joint meeting with Engineering Society of Northeastern Pennsylvania. March 23. Attendance 144.

Los Angeles

Impressions of Science and Engineering in Europe, by Dr. Paul Epstein, California Institute of Technology, and

Some Physical Aspects of Human Speech, by A. P. Hill, Southern California Telephone Co. Illustrated with motion picture. Preceded by a dinner. May 8. Attendance 78.

Lynn

Political Conditions in the Far East, by H. W. Bibber, Int. General Electric Co. April 11. Attendance 45.

The Electrical Transmission of Personality, and the Latest Developments in the Telephone Art and Television, by L. S. O'Roark, Bell Telephone Laboratories. Illustrated. April 25. Attendance 115.

Short-Circuit Phenomena in Synchronous Machines, by R. H. Park and I. H. Summers, General Electric Co. Illustrated. May 2. Attendance 43.

Mexico

Continuity of Service, by L. N. Blagoveschensky, The Mexican Lt. & Pr. Co. April 11. Attendance 16.

Minnesota

Chippewa Falls Hydroelectric Plant, by W. T. Walker, Northern States Power Co. Joint meeting with the Engineers Club of Minneapolis, preceded by a dinner. April 16. Attendance 300.

Social. February 1. Attendance 80.

Nebraska

Joint meeting with University of Nebraska and University of South Dakota Branches. During the day the students inspected the City of Omaha Water Pumping and Filtration Plant, the Overland Trail and Rubber Company and Omaha Steel Works. In the evening, a dinner was given for the students and faculty, after which the students provided a program consisting of music and technical discussions. April 26. Attendance 88.

Niagara Frontier

Inspection trip to Curtiss Aeroplane and Motor Company and the Consolidated Aircraft Corporation. December 8. Attendance 6.

Safety, by George Hays, Niagara Lockport and Ontario Power Co., and

Making Sound Visible and Light Audible, by J. B. Taylor, General Electric Co. A dinner preceded the meeting. March 23. Attendance 440.

Characteristics of Output Transformers, by J. M. Thompson, Ferranti Meter and Transformer Co., and

Shielding of Coils, Condensers, etc., by M. L. Levy, Stromberg-Carlson Telephone Mfg. Co. Joint meeting with Institute of Radio Engineers. April 11. Attendance 120.

Inspection trip to Curtiss Aeroplane and Motor Corp. and Consolidated Aircraft Corp. Joint with Engg. Society of Buffalo, American Welding Society, Society of Automotive Engrs., and Engg. Institute of Canada. April 17. Attendance 150.

Developments of Airport Lighting, by H. C. Ritchie, General Electric Co.;

Recent Progress in Aeronautics, by C. R. Keyes, Curtiss Aeroplane Corp., and

Research in Aeronautics by High-Speed Motion Pictures, by Marsden Ware, A. S. M. E. A dinner preceded the meeting. April 17. Attendance 475.

Insulation and Protection of Transmission Lines Against Lightning, by C. L. Fortescue, Westinghouse Electric & Mfg. Co. Illustrated. The following officers were elected: Chairman: G. H. Calkins; Secretary-Treasurer, E. P. Harder. April 20. Attendance 120.

Philadelphia

Household Utilization of Electricity, by E. W. Commery, National Electric Lamp Works; Miss Gertrude G. Shearer, Philadelphia Electric Co., and Stephen Bennis, United Electric Light & Power Co. Joint meeting with Illuminating Engineering Society. A dinner preceded the meeting. April 9. Attendance 100.

Pittsburgh

Arc Phenomena, by Joseph Slepian, Westinghouse Electric & Mfg. Co. April 10. Attendance 160.

Pittsfield

Calendar Reform, by F. W. Keough. Joint with Chamber of Commerce. April 27. Attendance 75.

Portland

Inspection trip to Portland's new sea wall. March 21. Attendance 300.

A Program of Engineering Education and Service, by Dean H. S. Rodgers, Oregon State College. April 25. Attendance 65.

Providence

The Importance of Clear Fused Quarts in Science and Industry, by E. R. Berry, General Electric Co. The following officers were elected: Chairman, A. E. Watson; Vice-Chairman, A. K. MacNaughton; Secretary-Treasurer, F. W. Smith;

Executive Committee, R. C. Patton, L. C. Eddy. A dinner preceded the meeting. Joint with Illuminating Engineering Society. May 8. Attendance 90.

Rochester

Carrier-Current Communication and Control, by C. A. Boddie, Westinghouse Electric & Mfg. Co. A dinner preceded the meeting. April 6. Attendance 43.

St. Louis

Arc Welding, by K. P. Hanson. The following officers were elected: Chairman, C. P. Potter; Vice-Chairman, G. H. Quermann; Secretary-Treasurer, E. G. McLagan. April 18. Attendance 65.

San Francisco

Reflection of 1.5 Meter Radio Waves, by L. J. Black and W. G. Wagoner, University of California;

Study of High-Voltage Flashovers, by J. T. Lusignan, Stanford University, and

Power-Line Radio Interference, by R. A. MacIntyre and C. H. LeBorgne, University of California. Demonstration of high-voltage phenomena at Ryan High-Voltage Laboratory. Joint meeting with University of California and Stanford University Branches. April 13. Attendance 162.

Inspection trip to Airplane Carrier U. S. S. *Saratoga*. Joint with A. S. N. E. and A. S. C. E. April 19. Attendance 500.

Saskatchewan

Joint meeting with Engineering Institute of Canada. March 25. Attendance 50.

Power Distribution, by E. W. Bull, Supt. of Light and Power, City of Regina. Annual meeting. The following officers were elected: Chairman, E. W. Bull; Secretary-Treasurer, W. P. Brattle. April 27. Attendance 36.

Schenectady

Substitutes for Experience, by Dr. Max Mason, President, University of Chicago. April 14. Attendance 400.

Annual Meeting. The following officers were elected: Chairman, E. S. Lee; Vice-Chairmen, R. F. Franklin, E. S. Henningsen, and F. W. Grover; Secretary E. E. Johnson; Treasurer, W. A. Sredenschek. April 27. Attendance 10.

Seattle

Introductory address by E. S. Goodwin, Chairman of the City Planning Commission;

Activities of the City Planning Commission, by E. B. Hussey, Consulting Engr.;

The Arterial Streets and Highways System, by W. C. Morse, City Engineer, and

The Architectural Features of Seattle's Ornamental Street Lighting, by C. F. Gould, Architect. Joint meeting with A. S. M. E., A. S. C. E. and A. I. M. E. March 23. Attendance 145.

An Electrical Method of Igniting Stumps in Land-Clearing Operations, by Erling Horn. (Presented by J. M. Rathbun, student);

Some Applications in Elementary Transients, by R. W. Barker, student;

The Dufour Cathode-Ray Oscillograph, by R. W. Joyce, student, and

Characteristics of the Fynn-Weichsel Motor as a Self-Excited Generator, by Herman Reise, student. Joint meeting with University of Washington Branch. April 17. Attendance 77.

Sharon

The Place of the Utility in an Economic Structure, by C. S. MacCalla, Pennsylvania-Ohio Power and Light Co. A dinner preceded the meeting. In the afternoon an inspection trip was made over the properties of the Pennsylvania-Ohio Power & Light Co. March 10. Attendance 200.

Developments in Power Generation and Transmission, by F. C. Hanker, Westinghouse Electric & Mfg. Co. April 3. Attendance 163.

Spokane

The Mechanical Analogy of the Problem of Transmission Stability, by V. B. Wilfley, Westinghouse Electric & Mfg. Co. February 10. Attendance 33.

The Chelan Project of the Washington Water Power Company, by J. B. Fisken. Joint meeting with A. S. M. E., A. S. C. E. and A. I. M. E. February 28. Attendance 150.

Lightning, by L. R. Gamble, The Washington Water Power Co. Illustrated by motion picture. April 27. Attendance 20.

Syracuse

The Reproduction of Sound, by C. R. Hanna, Westinghouse Electric & Mfg. Co. April 16. Attendance 153.

Toledo

Electric Furnaces in the Production of Steel, by Joseph Tillman, Industrial Steel Castings Co. April 13. Attendance 30.

Toronto

Joint Luncheon meeting with E. I. C. and A. S. M. E. Speaker: Prof. Peter Gillespie, University of Toronto. December 1. Attendance 225.

Modern Air-Circuit-Breaker Practise, by W. M. Scott, Jr., Cutter Electrical and Mfg. Co. January 13. Attendance 66.

The Study of Transmission-Line Power Arcs, by Paul Ackerman, Consulting Engineer. March 23. Attendance 121.

B-Battery Eliminators, by Prof. H. W. Price, University of Toronto. April 13. Attendance 162.

Joint Banquet with Institute of Radio Engrs. April 19. Attendance 150.

General Industrial Power Applications, by G. E. Stoltz, Westinghouse Electric & Mfg. Co. Joint meeting with E. I. C. April 27. Attendance 200.

Urbana

Advances in Electrical Transmission of Speech and Music, by Burke Smith, Illinois Bell Telephone Co. February 29. Attendance 116.

The Trend of Power Development, by A. D. Bailey, Commonwealth Edison Co. April 17. Attendance 143.

Utah

Radio Interference, by J. J. Jakosky, Radiore Company. Illustrated by slides. February 14. Attendance 200.

Power Control with Particular Reference to Vacuum-Type Circuit Breakers, by H. E. Mendenhall, University of Utah. March 27. Attendance 60.

Aviation Progress and Lighting of Airways for Night Flying, by L. C. Porter, General Electric Co. Illustrated with slides. April 25. Attendance 60.

Vancouver

Railway Motors, by H. M. Lloyd, B. C. E. R. Co. May 1. Attendance 21.

Washington, D. C.

Lightning Protection for Transmission Lines and Apparatus, by K. B. McEachron, General Electric Co. The following officers were elected: Chairman, L. D. Bliss; Vice-Chairman, W. A. E. Doying; Secretary-Treasurer, R. W. Cushing. May 8. Attendance 95.

Worcester

Selection and Efficiency of Electric Motors, by H. A. Maxfield, Worcester Polytechnic Institute. April 26. Attendance 40.

A. I. E. E. Student Activities

STUDENT CONFERENCE AND CONVENTION HELD IN NORTH EASTERN DISTRICT

Following extensive plans made by the District Committee on Student Activities, the programs given below were presented on Friday morning May 11 in connection with the Regional Meeting of District No. 1, held at New Haven, Connecticut, May 9-12, 1928.

9:00 a. m.

Student Branch Activities

R. F. Scott, Chairman University of Maine Branch, presiding.

The Institute and the Student Branches, Professor Harold B. Smith, Worcester Polytechnic Institute.

What Branch Membership Can Do for the Students, T. B. Miner, Rhode Island State College.

What Services Can a Student Branch Render to the College? Reo Miles, Syracuse University.

Planning and Publicity for Meetings, G. L. Rogers, Chairman Clarkson College of Technology Branch.

General Discussion of Branch Activities. Summary of Symposium, Professor Charles F. Scott, Counselor Yale University Branch.

10:30 a. m.

Technical Session

W. J. Brown, Chairman Yale University Branch, presiding.

An Accuracy Test for Flux Plotting Methods, R. B. Wright and N. F. Tsang, Massachusetts Institute of Technology. (Presented by R. B. Wright).

Special Oscillograph Studies of Alternator Short-Circuits, J. R. Burnett, and S. R. Knapp, Cornell University. (Presented by J. R. Burnett).

The Constant Impedance Circuit Applied to Wattmeter Calibration, Charles J. Augustine, Yale University.

Some Characteristics of Photoelectric Cells, Wendall F. Hess, Rensselaer Polytechnic Institute.

Servicing the Electric Consumer, Osborne W. Briden, Brown University.

A Comparison of Methods of Crest Voltage Measurement, William J. Brown and Blair Foulds, Yale University, (Presented by Blair Foulds).

12:30 p. m.

Luncheon Conference—Counselors and Incoming Branch Chairmen

At the luncheon conference, held immediately after the adjournment of the technical session, Professor F. M. Sebast, Counselor Rensselaer Polytechnic Institute Branch, was elected Chairman of the District Committee on Student Activities for the administrative year beginning August 1, 1928, and Professor W. H. Timbie, present Chairman of the Committee, was elected Counselor Delegate to represent the Committee at the Summer Convention in Denver.

Tentative plans for holding a District student convention next year were discussed.

After the adjournment of this session, the incoming Branch Chairmen present elected the four named below as members of a student committee to cooperate with the District Committee on Student Activities:

R. W. Miner, Yale University, Chairman.
F. J. McGowan, Jr., Worcester Polytechnic Institute.
E. A. Michelman, Massachusetts Institute of Technology.
A. V. Smith, University of Maine.

The attendance during the morning sessions was about 200, and the students showed keen interest in the papers and discussion on Branch activities as well as in those on technical subjects. In addition to a considerable number of Yale University students, there were present more than 100 students from twelve schools in the District.

STUDENT BRANCH ORGANIZED AT UNIVERSITY OF VERMONT

The establishment of a Student Branch at the University of Vermont was authorized by the Board of Directors on April 6, 1928. The Branch was organized on April 17, when By-laws were adopted and temporary officers were elected. At a meeting held on May 8, the following officers were elected to take office immediately and serve for one year: Chairman, Frank L. Sulloway; Vice-Chairman, Kenneth H. MacGibbon; Secretary-Treasurer, Lawrence G. Cowles. Professor Leonard P. Dickinson has been appointed Counselor. Meetings will be held on second and fourth Tuesdays.

ANNUAL COLLEGE BRANCH NIGHT OF DENVER SECTION

The annual student meeting of the Denver Section was held on May 11, 1928, and the following papers were presented:

The Application of the Photoelectric Cell to Measurements of Differences of Light Intensity, G. K. Baker, L. L. Booth, and R. G. Hays, University of Denver Seniors.

Magnetic Properties of Iron, Edwin Whitehead, University of Colorado, '28.

Electric Power in the Modern Cement Plant, Harold P. Groat, Colorado State Agricultural College, '28.

Phase Advancer for Induction Motors, R. A. Shields, University of Colorado, '28.

All of the papers were well prepared and presented, and much enthusiasm was shown by both students and members of the Section. The attendance was 94.

STUDENT PROGRAM AT SEATTLE SECTION MEETING

The Seattle Section and the University of Washington Branch held a joint meeting on April 17, 1928, at which the following student papers were presented:

An Electrical Method of Igniting Stumps in Land Clearing Operations, Erling Horn. (Presented by J. M. Rathbun).

Some Applications in Elementary Transients, Robert W. Barker.

The Dufour Cathode Ray Oscillograph, R. W. Joyce.

Characteristics of the Fynn-Weichsel Motor as a Self-Excited Generator, Herman Reise.

JOINT MEETING OF SAN FRANCISCO SECTION AND NEIGHBORING BRANCHES

The San Francisco Section and the Student Branches located at the University of California, University of Santa Clara, and Stanford University held a joint dinner meeting at Stanford University on April 13, 1928. Mr. W. L. Winter, Chairman of the San Francisco Section, presided.

After a brief informal talk by Dr. Harris J. Ryan, the following student papers were presented:

Reflection of 1½ Meter Radio Waves, L. J. Black and W. G. Wagner, University of California. (Presented by W. G. Wagner)

A Study of High-Voltage Flashovers, J. T. Lusignan, Stanford University.

Power Line Radio Interference, R. A. MacIntyre and C. H. Le Borgne, University of Santa Clara. (Presented by R. A. MacIntyre).

Following the presentation of the papers, an interesting and instructive demonstration of high voltage phenomena was given in the Ryan High Voltage Laboratory.

The attendance was about 100 at the dinner and about 160 during the program.

STUDENT MEETING HELD BY NEBRASKA SECTION

The Nebraska Section entertained the members of the University of Nebraska and University of South Dakota Branches with inspection trips and a dinner on April 26, 1928, and a student program was presented at a joint meeting in the evening. The complete program is given below.

Inspection, Florence Water Works.
Luncheon at Florence Water Works.
Inspection, Overland Trail Rubber Co. Omaha Steel Works.
Dinner at University Club.

Factors Affecting the Adjustment of Railroad Rates, F. J. Knights, University of Nebraska, '28.

Remarks by Dr. B. B. Brackett, University of South Dakota and Dean O. J. Ferguson, University of Nebraska.

The Vacuum Tube Oscillator, L. F. Leuck, University of Nebraska, '28.

The South Dakota Student's Viewpoint, C. R. Cantonwine, University of South Dakota, '29.

Several musical numbers were rendered by the students during the evening program.

The meeting was enjoyed very much by members of the Section and the students. Twenty students of the University of South Dakota were present, and the attendance at the evening meeting was 88.

BRANCH MEETINGS

Alabama Polytechnic Institute

The Engineer and the Community, by R. H. Boyd, student;

The Life and Works of Hugh L. Cooper, by J. H. Gerber, student;

Grinding and Testing of Concave Mirrors, by E. R. Hauser, student, and

House Wiring, by G. M. Ross, student. March 22. Attendance 59.

Following talks given by freshmen and sophomores: *The Life and Works of Joseph Henry*, by D. O. Baird; *Industrial Lighting*, by O. T. Allen; *Warrior Unit Pulverizer*, by W. M. Shaup, and *Electric Refrigeration*, by J. A. Willman. April 5. Attendance 31.

Design of Steam Boilers, Superheaters, and Economizers, by C. A. Weston, Babcock and Wilcox Co. Motion picture, entitled "Steam," was shown. April 12. Attendance 48.

Life of Alexander Graham Bell, by E. Walters;

Methods of Early Train Control on Railroads, by L. C. Yancey; and

The Road to Success, by H. Hickman. April 19. Attendance 58.

Business Meeting. The following officers were elected: Chairman, W. P. Smith; Vice-Chairman, C. D. Bradley; Secretary-Treasurer, C. W. Meyer; Auburn Engineer Reporter, E. R. Jones; and Plainsman Reporter, H. Hickman. April 26. Attendance 50.

University of Arizona

Business Meeting. February 13. Attendance 11.

Michael Faraday, by Jack Hopper, and

Thomas A. Edison, by Ray Humbert. February 20. Attendance 10.

Joseph Henry, by George Blount, and

Lord Kelvin, by George Harding. February 27. Attendance 11.

Motion picture, entitled "The Life of Edison," was shown. March 5. Attendance 12.

George Westinghouse, by George Lynn, and

Benjamin G. Lamme, by Gene Magee. March 12. Attendance 10.

Charles P. Steinmetz, by Joe Sigler. Motion picture, entitled "The Manufacture of Telephones." March 19. Attendance 11.

Michael I. Pupin, by George Blount, and

The Work of the Institute, by George Harding. March 26. Attendance 10.

The History of Incandescent Lamps, by Jack Hopper, and

The Story of the Telephone, by Ray Humbert. Motion picture, entitled "The Making of Mazda Lamps." April 2. Attendance 12.

The Historical Development of the Transformer, by George Lynn. April 9. Attendance 11.

Motion picture, entitled "The Transformer," was shown. April 16. Attendance 13.

Experience as Engineer and Executive, by Max Pooler. Smoker. April 20. Attendance 17.

Armour Institute of Technology

Vacuum Tube Characteristics, by J. H. Miller, Jewell Electrical Instrument Co. March 29. Attendance 50.

Bucknell University

Business Meeting. April 16. Attendance 20.

California Institute of Technology

Distribution Problems, by E. L. Bettanier, Pasadena Municipal Light and Power Co. April 17. Attendance 14.

A motion picture, entitled "Portable Electricity," was shown. April 26. Attendance 10.

A motion picture, entitled "The Single Ridge," was shown. May 3. Attendance 10.

University of California

Joint meeting. April 13. (See report elsewhere in Student Activities department).

The Transmission of Radio Programs over Telephone Circuits, by R. M. Elliott, Pacific Tel. & Tel. Co. Joint meeting with A. S. M. E. and A. E. & M. E. Business session. Nomination of officers. The following elected on April 20th: Chairman, H. H. Hyde; Vice-Chairman, C. W. Mors; Secretary, H. K. Morgan; Treasurer, J. B. Gillham; Executive Committee; L. G. Levoy and W. G. Wagener. April 18. Attendance 55.

Catholic University of America

Business Meeting. Election of officers. April 16. Attendance 20.

Clarkson College of Technology

Experiences with the Philadelphia Electric Company, by L. B. Dyke, student, and

G. E. Test Course, by Mr. Powell, St. Lawrence Valley Power Co. Refreshments were served. April 12. Attendance 22.

Business Meeting. Election of officers. May 2. Attendance 65.

Clemson College

Salesmanship Competition (Papers on Circuit Breakers), by M. A. Jones and H. E. Stoppelbein, and

Current Events, by L. F. Sander. April 12. Attendance 18.

Conductivity of Crystals, by Dr. H. M. Brown, and

Report of Student Activities Conference at Atlanta, by A. P. Wylie, Chairman. April 26. Attendance 29.

Colorado Agricultural College

Business Meeting. Discussion of the inspection trip planned for May 10 and 11. Plans announced for participation of the Branch in "College Night" program of Denver Section on May 11. April 16. Attendance 15.

University of Colorado

The New Turbine Unit Installed in Plant of Gates Rubber Company, by C. R. Ahlquist, Chief Engr. Refreshments were served. April 4. Attendance 35.

Economic and Commercial Aspects of the Natural Gas Line from Texas to Denver, by F. T. Parks, Mgr., Natural Gas Division, Public Service Co. April 18. Attendance 29.

University of Denver

Business Meeting. Announcement of plans for participation in the "College Night" meeting of the Denver Section on May 11th. Discussion of plans for Electrical Show to be held on May 17. May 3. Attendance 28.

Drexel Institute

Business Meeting. Election of officers for next year: Chairman, D. M. Way; Vice-Chairman, G. L. Oddy; Secretary, C. W. Kenyon; Treasurer, R. M. Heckman. April 18. Attendance 15.

University of Florida

Television: Photo-Telegraphy, and Transoceanic Telegraphy, by Col. R. L. Boyd, Southern Bell Tel. & Tel. Co. Slides. April 9. Attendance 25.

Business Meeting. The following officers were elected for 1928-29: Chairman, A. W. Payne; Vice-Chairman, L. C. Moore; Secretary-Treasurer, N. J. Rogers. Refreshments were served. May 7. Attendance 25.

Georgia School of Technology

Business Meeting. May 1. Attendance 64.

University of Idaho

Business Meeting. Discussion and reports concerning Engineers Day. April 26. Attendance 34.

Kansas State College

Trip Through a Wire Drawing Plant, by J. L. Potter. Film, entitled "Electrical Measuring Instruments." April 2. Attendance 78.

Patents and Inventions, by Prof. R. G. Kloeffler, Counselor. Film, entitled "Erecting Outdoor Substation." April 10. Attendance 79.

University of Kansas

The New Gas Compressor Station of Cities Service Company at Ottawa, by Ralph Vinson, student. Refreshments were served. April 12. Attendance 47.

J. M. Gonzalez and Shadrach Paul gave illustrated talks on their native countries, Mexico and India, respectively. Three reels on the making of insulated wire and cables were shown. April 26. Attendance 49.

Business Meeting. Election of officers. May 10. Attendance 52.

Lafayette College

Business Meeting. May 5. Attendance 22.

Lehigh University

Fire Alarm Systems, by W. W. Hocke, student, and

Electrical Maintenance in an Industrial Plant, by A. J. Standing, Supt. of Electrical Dept., Saucon Division, Bethlehem

Steel Co. Short talks by L. K. Somers and R. S. Taylor on the regional meeting at Baltimore. The following officers were elected: Chairman, S. R. Van Blarcom; Vice-Chairman, J. E. Wightman; Secretary, R. S. Taylor; Treasurer, L. K. Savers. Presentation of award for best student paper delivered this year to W. W. Hocke by C. E. Krause, Chairman of Prize Award Committee. Refreshments served. May 11. Attendance 41.

Lewis Institute

Application of Electricity to Railways, by W. D. Bearce, General Electric Co. Joint meeting with Armour Institute of Technology Branch. May 4. Attendance 135.

Louisiana State University

The Production Side of the Electrical Business, by Mr. Davies, Baton Rouge Electric Co. April 19. Attendance 18.

University of Maine

Switchboards and Protective Devices, by Prof. W. E. Barrows, Jr., Counselor. Film, entitled "Switchboard Travelogue." The following officers for 1928-29 were elected: Chairman, A. V. Smith; Vice-Chairman, E. G. Horton; and Secretary-Treasurer, G. A. Whittier. April 18. Attendance 21.

Marquette University

Hydroelectric Development in California, by Mr. Fowler, Hydraulic Engr., Allis-Chalmers Mfg. Co. Joint meeting Marquette Branches A. S. M. E. and A. I. E. E., and Student Chapter, A. S. C. E. April 10. Attendance 117.

Reyrolle Switchgear, by Donald Greensward, Allis-Chalmers Mfg. Co. Slides. April 26. Attendance 17.

Massachusetts Institute of Technology

Theory of Public Utility Rate Forms and Their Application to Different Territories, by L. R. Nash, Vice-President, Operating Division, Stone & Webster, Inc. April 5. Attendance 150.

Michigan Stage College

Application of Electricity to Railroads, by W. D. Bearce, General Electric Co. Amendments to Constitution and By-laws adopted. May 7. Attendance 43.

University of Michigan

The Application of Electricity to Railway Operation, by W. D. Bearce, General Electric Co. Slides. April 30. Attendance 22.

University of Minnesota

Relationship of the Student Engineer to the A. I. E. E. and to the Profession Itself, by Mr. Bellows of Radio Station WCCO and Mr. Parks, Western Union Tel. Co. Demonstraton of a demand metering system. March 29. Attendance 58.

Inspection trip to Main and Atlantic Exchanges of the Northwestern Bell Tel. Co. in Minneapolis. Illustrated lecture, entitled "Voices Across the Sea." April 25. Attendance 60.

Mississippi A. & M. College

Electric Switching Equipment, by L. H. Calloway, student, Two-reel moving picture "The Wizardry of Wireless." Appointment of nominating committee and discussion of plans for annual banquet. April 19. Attendance 40.

University of Missouri

The Manufacture of Insulators, by D. C. Carroway, Locke Insulator Corp. April 27. Attendance 28.

Montana State College

The Earth's Electric Charge, by W. E. Howe. April 5. Attendance 96.

Interference Problems in Line Telephony, by C. F. Seamore, Mountain States Tel. & Tel. Co., Helena, Mont. Luncheon. April 19. Attendance 251.

University of Nebraska

Business Meeting. The following officers were elected: Chairman, G. W. Cowley; Vice-Chairman, K. T. Davis; Secretary-Treasurer, L. T. Anderson. Refreshments. April 18. Attendance 26.

University of Nevada

Business Meeting. "Suggested By-laws for Student Branches" adopted. April 25. Attendance 18.

Newark College of Engineering

Automatic Railway Substations and *Engineering Characteristics of a Three-Thousand Volt Locomotive,* by Prof. J. C. Peet, Counselor. Illustrated. The paper to be presented by the Branch at the New York Student Convention was presented. April 2. Attendance 25.

Design, Construction and Application of A-C. and D-C. Motors, by M. L. Parker, Industrial Motor Specialist, General Electric Co. April 16. Attendance 35.

University of New Hampshire

Motion pictures, entitled respectively "Telephone Inventors of Today," and "Modern Telephone Workshop," were shown. February 6. Attendance 36.

Film, entitled "Power," was shown. April 7. Attendance 35.

Radio Communication on Trains, by Messrs. Sumner and Colby;

The Earth's Electric Charge, by G. Vatcher, and

Lightning Protection of Isolated Areas, by Messrs. Wendell and Whitten. The following officers were elected: President, N. J. Pierce; Secretary, M. W. Cummings. April 14. Attendance 36.

Fuses, by F. E. Beede and H. E. Fuller;

East River Station of the New York Edison, by S. S. Appleton and M. Cummings, and

Atomic Hydrogen Welding, by G. P. Balch and T. Elliot. April 21. Attendance 26.

College of the City of New York

Industrial Control, by I. C. Diefenderfer, General Electric Co. Slides. April 26. Attendance 38.

Subway Construction in New York City, by R. Ridgeway. Illustrated. Joint meeting CCNY Branch, A. I. E. E., and Student Chapter, A. S. C. E. May 3. Attendance 37.

New York University

The Shield Grid Radio Tube, by J. F. Torpie, student, and

Band Pass Filters, by Zolman Benin, student. April 12. Attendance 40.

Radio Receiver Performance and How to Measure It, by H. W. Appel, student, and

An Investigation of Audio Frequency Amplification Test Apparatus, by M. A. Forrest, student. May 3. Attendance 32.

North Carolina State College

Business Meeting. The following officers were elected: President, O. M. Carpenter; Vice-President, C. H. Harshaw; Secretary-Treasurer, W. E. Moseley; and Reporter, J. A. Taylor. April 24. Attendance 16.

Inspection trip to Raleigh Office of the Western Union Telegraph Co. May 1. Attendance 8.

Business Meeting. May 8. Attendance 11.

University of North Dakota

The Construction of Transmission Lines, by C. H. Billingley, General Supt., Red River Power Co., Grand Forks, N. D. A still film on "The Electric Car Dumper," was shown. May 3. Attendance 22.

Northeastern University

Inspection trip to River Works, General Electric Co., Lynn, Mass. April 20. Attendance 27.

Conowingo Hydroelectric Power Development, by Carl Burrough, Stone and Webster, Inc. Two films. April 24. Attendance 95.

Business Meeting. The following officers were elected: Chairman, R. W. Cleveland; Vice-Chairman, C. P. Goeller; Secretary, H. F. Wilder; and Treasurer, O. E. Hartford. May 5.

Ohio State University

The Application of Electricity to Mining, by J. S. Beltz, Jeffrey Mfg. Co. April 6. Attendance 50.

Past, Present, and Future of Engineering Education, by Dean E. A. Hitchcock, College of Engineering. April 19. Attendance 40.

Oklahoma A. & M. College

Importance of Safety, by Prof. Edwin Kurtz, Counselor, and

Our First-Aid Team, by Mr. Fisher, Oklahoma City. Demonstrations of resuscitation. April 25. Attendance 61.

Oregon State College

Application of Electricity to the Manufacture of Pulp and Paper, by C. W. Fick, Northwestern Engineer, General Electric Co. Motion pictures. Henry Moreland elected to represent the Branch on the Executive Board of the Associated Engineers of the Oregon State College. Refreshments. April 11. Attendance 45.

Business Meeting. Nomination of officers for next year. Discussion of plans for attending joint meeting with Portland Section on May 25 at which the Branch will supply the program. May 3. Attendance 32.

Pennsylvania State College

Application of Magnetic Field Studies to Electrical Engineering, by E. E. Johnson, General Electric Co. Illustrated. March 15. Attendance 58.

University of Pittsburgh

Some of the Problems in Public Utility Work, by R. L. Kirk, Asst. to Manager, Planning Division, Duquesne Light Co. April 13. Attendance 43.

Joint Meeting with Engineering Association. April 20. Attendance 150.

Subway Construction, by R. P. Snyder, student, and

Manufacture of Automobile Tires and Tubes, by J. J. Pfeiffer, student. April 27. Attendance 37.

Purdue University

Constant Frequency Control, by P. O. Penn, student, and

High-Frequency Oil-Insulated Oscillator, by W. E. Brown, student. April 17. Attendance 30.

Application of Electricity to Railway Operation, by W. D. Bearce, General Electric Co. The following officers were elected: Chairman, J. F. Nuner; Vice-Chairman, W. H. C. Higgins; Secretary, P. C. Sandretto; Treasurer, P. D. Deckard. May 2. Attendance 40.

Rensselaer Polytechnic Institute

Recent Developments in Long Toll Telephone Cables and Associated Equipment, by H. S. Sheppard, Executive Asst., Dept. of Research and Development, American Tel. & Tel. Co. Illustrated by slides and one-reel motion picture. April 10. Attendance 140.

Rhode Island State College

L. F. McCluskey, student, gave a demonstration of spot welding with a short talk on its uses. February 24. Attendance 20.

Whistling and Talking Arcs, by Prof. W. A. Anderson, Counselor. Arthur Z. Smith, student, gave an exhibition of the whistling arc and an explanation of the phenomena. March 2. Attendance 21.

Manufacture of Precision Electrical Instruments, by A. F. Corby, Weston Electrical Instrument Corp. Motion pictures. March 9. Attendance 41.

Standards of Deafness, by W. H. Gannon, student, and

Arc Welding and Its Uses, by Eugene Rodrick, student. March 16. Attendance 20.

Motion picture, entitled "From Coal to Electricity," was shown. March 23. Attendance 43.

Life of B. G. Lamme, by L. A. Bloomer, student, and

Life of Charles P. Steinmetz, by W. F. Smith, student. Prof. W. A. Anderson, Counselor, announced the Regional Meeting at New Haven. March 30. Attendance 22.

Prof. W. A. Anderson, Counselor, gave an outline of the Regional Meeting at New Haven and asked the members to cooperate by sending a paper to the meeting. April 13. Attendance 19.

Salvage Operations on the Sunken Submarine S-4, by Thomas Eadie. Mr. Eadie demonstrated his diving suit and diving apparatus. April 19. Attendance 111.

The Life of Professor Michael Pupin, by T. B. Miner, student. April 20. Attendance 22.

Two motion pictures, entitled respectively "Anthracite" and "An Electrified Travelogue," were shown. April 27. Attendance 50.

Rutgers University

Low-Voltage Network Relay, by E. C. Siddons. Slides on Westinghouse Plant. April 16. Attendance 12.

University of Santa Clara

Motion picture on "Electrical Measuring Instruments" was shown. April 17. Attendance 84.

University of South Dakota

Business Meeting. April 18. Attendance 14.

Joint meeting. April 26-27. (See report elsewhere in Student Activities department.)

Stanford University

The Practical Side of Engineering, by P. M. Downing, Vice-President, Pacific Gas and Electric Co. Music, refreshments and smokes. Joint smoker of Stanford University Branches of A. I. E. E., A. S. C. E., and the Geological and Mining Society of American Universities. April 11. Attendance 90.

Joint meeting. April 13. (See report elsewhere in Student Acitivites department.)

Stevens Institute of Technology

Smoker. Lecture by Mr. Davis, Mechanical Engineer. Joint, with A. S. M. E. Branch. February 15. Attendance 108.

Inspection trip to 44 West 27th Street Station of New York Edison Co. May 2. Attendance 17.

Swarthmore College

Banquet. Andrew Simpson, College Engr., spoke on some of the problems he had to solve in installing the 250-hp. Babcock and Wilcox boiler in the College power plant. Prof. Tryon, Massachusetts Institute of Technology spoke on the value of continuing engineering education at M. I. T. April 19. Attendance 45.

University of Tennessee

Lecture and moving pictures on Electrical Instruments. March 26. Attendance 10.

Business Meeting. March 29. Attendance 54.

University of Texas

J. B. Robuck, President, gave a report of the Regional Meeting of District No. 7 at St. Louis. March 13. Attendance 14.

Summer Experiences, by M. R. Chamberlain, student. G. E. Schmitt was elected Secretary. Plans for a Power Show were discussed and L. L. Antes and M. R. Chamberlain were appointed directors. April 12. Attendance 14.

Installing Protective Devices for Electric Machinery in a Cement Plant, by J. F. Hinton, student, and

Equipment in a Modern Substation, by H. A. Tankersley, student. April 26. Attendance 12.

Methods of Starting Induction Motors, by B. D. Bedford, student. May 11. Attendance 12.

University of Utah

Business Meeting. Plans were made for a joint meeting with the Utah Section, program to be furnished by Branch members. April 10. Attendance 16.

Business Meeting. The following officers were elected: Chairman, N. M. Chapman; Vice-Chairman, J. B. Hunter; Secretary, Garnett Littlefield. April 17. Attendance 20.

Inspection trip to Open-Cut Mine of Utah Copper Company, Bingham Canyon, Utah, and the Concentration Plant of the Utah Copper Company, Magna, Utah. April 18. Attendance 23.

University of Vermont

Organization of Branch and adoption of by-laws. Temporary officers elected to hold office until second Tuesday in May. Regular meetings to be held on second and fourth Tuesdays. Illustrated lecture on "Electrical Progress During 1926 and 1927," by Professor Leonard P. Dickinson, Head of Dept. of Elec. Engg. April 17. Attendance 18.

The Uses of Vacuum Tubes, by Prof. H. I. Williams, Dept. of Elec. Engg. Short business session. April 24. Attendance 18.

Business Meeting. Election of officers to take office immediately. May 8. Attendance 15.

The History and Development of the Electric Transformer, by Prof. R. O. Buchanan. Motion picture, entitled "Power Transformers." May 10. Attendance 32.

Virginia Military Institute

Purposes and Organization of A. I. E. E. as Learned from Atlanta Student Convention, by L. Gwathmey;

Japan from an Electrical Engineer's Viewpoint, by G. J. Hales, and

The Steel Tank Mercury-Arc Rectifier, by W. J. Halstead. April 9. Attendance 37.

Installation of New Third Rails, by R. C. Hanna;

Electric Power in the Army, by W. E. Hobbs;

Railway Electrification, by H. K. Moss, and

Electrical Advertising, by Mr. Green. April 23. Attendance 42.

Business Meeting. The following officers were elected for next year: Vice-Chairman, J. K. Davis; Secretary, R. A. Wright; Executive Committee, Jay Smith, Jr. April 25. Attendance 33.

Washington State College

Neon Signs, by Emmet Kuntze. Harold Low, E. Kuntze, and R. Dennis appointed to prepare for the Electrical Show. March 14. Attendance 40.

The Cathode Oscillograph, by Henry Kahl, student. March 28. Attendance 20.

Aluminum, by O. H. Wahl, student, and

Photoelectric Cell, by Raymond Dennis, student. April 11. Attendance 15.

Safety Work in Public Utilities, by J. B. Fisken, Consulting Engineer, Washington Water Power Co. April 26. Attendance 36.

Film, entitled "Telephone Manufacturing," April 25. Attendance 40.

Film, entitled "Electrified Travelogue." May 3. Attendance 18.

University of Washington

Forecasting in Engineering, by G. H. Smith, City of Seattle, Dept. of Lighting. April 12. Attendance 19.

Joint meeting with Seattle Section. April 17. Attendance 75. (See account elsewhere in Student Activities dept.)

Piezo-Crystal Phenomena, by Kermit Olson, student. It was announced that the E. E.'s had won the bi-annual Engineers Open House. April 26. Attendance 21.

Kress "B" Battery Eliminator, by Carl Radin, student. Business session. May 3. Attendance 11.

University of Wisconsin

Power Transformer Development, by R. D. Jordan, General Electric Co. Picture. March 12. Attendance 54.

Public Utility Rates, by J. C. Neff, Wisconsin Light and Power Co. Joint meeting with Madison Section. March 30. Attendance 50.

Worcester Polytechnic Institute

Theory of the Rocket, by Dr. R. H. Goddard, Clark University. Election of officers. April 9. Attendance 50.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES APRIL 1-30, 1928

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

AIRCRAFT HANDBOOK.

By Fred H. and Henry F. Colvin. 3rd edition. N. Y., McGraw-Hill Book Co., 1928. 464 pp., illus., diagrs., 8 x 5 in., fabrikoid. $4.00.

This handbook is intended primarily for the airplane mechanic. It contains practical information upon the operation and maintenance of the standard aircraft engines of the day, upon the rigging and assembling of aircraft, upon aircraft instruments, and upon flying regulations and airport construction.

AIRCRAFT YEAR BOOK, 1928. N. Y. Aeronautical Chamber of Commerce of America. Inc. 1928. 551 pp., illus., ports., maps, 9 x 6 in., cloth. $5.25.

Like the volumes for preceding years, this book affords a good summary of the epochal flights of 1927, of the development of civil and governmental aviation in the United States, and of technical and commercial developments in the industry. Foreign events are reviewed, an aeronautical chronology for the year is given, and there are numerous tabulations of information frequently needed by those engaged in this field.

AUS DEM REICH DER TECHNIK, v. 2.

By Max Maria von Weber. Berlin, V. D. I. Verlag, 1928. 336 pp., port., 8 x 6 in., cloth. 5.-r. m.

The success attained by the volume of stories by this famous engineer novelist, which Dr. Weihe published two years ago, has encouraged him to prepare a second volume of selections from Weber's writings. The stories in it are chiefly of a historical nature.

CAR BUILDERS' CYCLOPEDIA OF AMERICAN PRACTISE. Ed. 12, 1928. Comp. & edited for American Railway Association. Mechanical Division. N. Y., Simmons-Boardman Publ. Co., 1928. 1288 pp., illus., diagrs., 12 x 9 in., fabrikoid. $5.00.

In this edition the cyclopedia arrangement introduced in the tenth edition has been elaborated with good results. Each section now contains all the information on its subject, specifications, drawings, illustrations and manufacturers' data, so that reference is most convenient.

The book is indispensable to anyone interested in the design or construction of railroad cars of any type. It brings together the standards and practises of the American Railway Association, and illustrations and drawings of cars made by the leading railroad and car builders.

CENTURY OF INDUSTRIAL PROGRESS. Edited by Frederic William Wile. Garden City, N. Y., Doubleday, Doran & Co., for the American Institute of the City of New York, 1928. 381 pp., 10 x 7 in., cloth. $5.00.

In commemoration of its centennial, the American Institute of the City of New York has issued this volume of essays upon the industrial progress of the last century. Thirty authorities contribute accounts of the evolution of our industry and commerce along various major lines, such as agriculture, lumber, shipping, mining, steel, machinery, textiles, paper, printing, petroleum, merchandising, building and aviation. The book gives an excellent historical review of the period.

CHEMICAL EFFECTS OF ALPHA PARTICLES AND ELECTRONS.

By Samuel C. Lind. 2d edition. N. Y., Chemical Catalog Co., 1928. (Amer. Chemical Soc., Monograph series). 252 pp., diagrs., tables, 9 x 6 in., cloth. $5.00.

After six years, the author has found it necessary to revise this monograph completely and to add seven chapters. As

revised, the book again gives an up-to-date summary of the work that has been done in investigating the chemical effects of corpuscular radiation.

Der Einfluss Der Mittleren Hauptspannung Auf Das Fliessen Der Metalle.

By Walter Lode. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, heft 303. 15 pp., illus., diagrs., 12 x 9 in., paper. 2,50 r. m.

In order to calculate the safe load on structural members subjected to complicated stresses, the designer must know what, under usual conditions when stresses act in all directions, limits the beginning of any permanent change of shape.

Dr. Lode has investigated the so-called flow stresses, under which a metal of given strength undergoes permanent deformation, and compared their values at various combinations of tension in two directions at right angles to each other. He has tested the various hypotheses advanced by comparing them with the voluminous numerical data available in the literature, and by new, exact experiments. As a result, he is able to select a hypothesis that agrees to within 3 per cent with experimental determinations of the flow stresses.

The author also discusses the question of the manner in which a metal undergoes permanent extension or reduction when subjected to three stresses at right angles to each other.

Drang und Zwang, v, 2. 2d edition.

By Ang. & Ludwig Föppl. Mün. u. Ber., R. Oldenbourg, 1928. 382 pp., diagrs., tables, 10 x 7 in., cloth. 17,50 r. m.

"Stress and strain" is written for the engineer who is already familiar with investigations of the resistance of materials and with the simpler theory as given in the ordinary texts. It is intended as a continuation of Dr. Föppl's "Vorlesungen über technische Mechanik" and offers a deeper insight into the subject by discussion and investigation of more difficult questions and more advanced problems.

The new edition of volume two has been extensively revised, especially in the sections devoted to shells and to the torsional strength of bars.

Energiespeicherung.

By W. Pauer. (Wärmelehre und wärmewirtschaft in einzeldarstellungen, band VI). Dresden u. Lpz., Theodor Steinkopff, 1928. 179 pp., diagrs., 9 x 6 in., paper. 12,-r. m.

A general discussion of the methods of storing energy available for use in power plants. Flywheels and methods of storing water-power, the storage of heat in liquids and solids, and steam accumulators are all discussed, their properties set forth and their uses pointed out. The determination of maximum demands on power plants is considered. The book is a useful review of the various methods by which energy is stored, either purposely or as a more or less accidental byproduct.

Haushalt-Kaltemaschinen.

By R. Plank. Berlin, Julius Springer, 1928. 96 pp., illus., diagrs., 9 x 6 in., paper. 7,50 r. m.

During a tour of observation in America in 1927, Dr. Plank paid particular attention to household refrigeration. The results of his visit, together with those of his investigations of European apparatus, are given in this book. He points out the characteristics of compression and absorption machines, describes most of the machines on the market and compares critically the two types.

Handbook of Mechanical Refrigeration.

By H. J. Macintire. N. Y., John Wiley & Sons, 1928. 724 pp., illus., diagrs., tables, 9 x 6 in., fabrikoid. $7.50.

This book aims to include all the information upon mechanical refrigeration which the engineer is likely to need. It presents some theory as a basis for the fundamental formulas as well as all the information required for understanding the design and operation of various systems.

Starting with the compressor, the author deals with absorption machines, fittings, condensers, automatic machines, refrigerants, brine systems, water supply, erection, operation and testing. He then considers ice making, cold storage, air cooling and conditioning, hotel and apartment refrigeration and refrigeration in the chemical industries, safety devices, fire protection, costs, specifications, motors and engines are also discussed.

Hilfsbuch Fur Die Elektrotechnik; Schwachstromausgabe.

Edited by Karl Strecker. 10th edition. Berlin. Julius Springer, 1928. 1137 pp., diagrs., tables, 8 x 5 in., cloth. 42.- r. m.

This well-known handbook, having outgrown the limits of a single volume, has been divided into two, covering respectively heavy-current engineering and weak-current engineering.

The present volume, on weak currents, contains first the general mathematical and electrical data common to both fields. Following this, the book presents a great mass of in formation upon wired and wireless telegraphy and telephony. The book is the joint effort of numerous specialists.

Induction Motor Practice.

By A. M. Dudley. N. Y., McGraw-Hill Book Co., 1928. 236 pp., illus., diagrs., 9 x 6 in., cloth. $2.50.

A discussion by a designer of induction motors, on the rotating magnetic field, the mechanical, electrical, and operating characteristics, the control, and the circle diagram. The answers to practical questions published in the *Electric Journal* are also included. The book supplements the author's earlier work on induction motors, in which windings were considered, by considering matters of operation and performance. Mathematical formulas are avoided in favor of simple language.

Lautal Als Baustoff Für Flugzeuge.

By Paul Brenner. (Luftfahrtforschung, bd. 1, heft 2, 15 Feb. 1928). München, R. Oldenbourg, 1928. 60 pp., illus., 11 x 8 in., paper. 11,25 r. m.

This pamphlet gives the results of extensive tests of a new aluminum-copper-silicon alloy, "lautal." The tests undertaken to determine the suitability of lautal for use in aircraft construction, investigated its mechanical properties in the ordinary state, the effect of various heat treatments, its resistance to corrosion, etc. Comparisons with duralumin are made throughout. The tests were made at the German Aeronautical Testing Laboratory in Berlin.

Manuel Du Mécanicien Électricien.

By H. de Graffigny. Paris, Gauthier-Villars et cie., 1928. 227 pp., illus., 7 x 5 in., boards. 15 fr.

A manual of practical information for linesmen and powerhouse attendants. Treats of dynamo testing and operating, a-c. and d-c. motors, mechanical transmissions, wiring, etc.

Physics for College Students.

By A. A. Knowlton. N. Y., McGraw-Hill Book Co., 1928. 641 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.75.

Dr. Knowlton has written a very interesting textbook. His problem has been to present the subject in a way that will attract and hold the attention of students of college grade who are not interested in physics as a basis for engineering, but as part of a liberal education.

To meet their requirements he has reselected and rearranged his materials. The traditional divisions of mechanics, sound, etc. have been abandoned and physics treated as a unit, with energy the central theme. The fundamentals of all fields are introduced rapidly, and various subjects reappear again and again as the student progresses. Much space is given to the "new physics."

Rise of Modern Physics.

By Henry Crew. Baltimore, Williams & Wilkins Co., 1928. 356 pp., illus., ports., 8 x 5 in., cloth. $5.00.

A brief, readable history of the development of physics from its beginnings to present times. The book is intended for readers who have had little previous knowledge of the subject; to them it offers an informal introduction to the science and to the men who have guided its development.

The Great Physicists.

By Ivor B. Hart. Lond., Methuen & Co., 1928. 138 pp., diagrs., 7 x 4 in., cloth. 3/6.

Dr. Hart's little book is a brief, readable outline of the development of physics, told through the lives and achievements of the greatest physicists from antiquity to the present day. It is admirably adapted to the needs of the intelligent reader who wishes to review the main features of its evolution.

Transmission Line Engineering.

By W. W. Lewis. N. Y., McGraw-Hill Book Co., 1928. 361 pp., diagrs., tables, 9 x 6 in., cloth. $4.00.

Discusses from both theoretical and practical points of view, the more important electrical problems in the calculation and design of transmission lines. Includes what is necessary for finding or calculating the resistance, inductance and capacity of transmission lines, the losses in them and their regulation and efficiency. Directions for calculating short-circuit currents are given, and connections and disturbances are discussed. Power limits and grounding systems are considered.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary; temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

CABLE ENGINEER, to work in large middle-western utility on specifications, tests and research on underground power cable and allied problems. Graduate of electrical engineering course with one to three years' experience, not necessarily on cable work. Apply by letter. X-4927-C.

MEN AVAILABLE

ASSISTANT ELECTRICAL ENGINEER, 32, married. University graduate; seven years' experience, testing, construction, design of substations, design of tower and pole lines, electrical calculations, estimates, studies. Now employed, desires connection with utility or manufacturer. Location, New York City or Chicago. B-8043.

ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING, 38, married. B. S. in E. E. and E. E. degrees, General Electric Test and nine years' experience in state universities; desires position as head of department or professor of electrical engineering in a first class university or engineering school. Location preferred, West. C-4403.

ELECTRICAL ENGINEER, graduate, 26, married. 1½ years on General Electric Test in Schenectady. 1½ years as Power Engineer and 1 year as Distribution Engineer with public utility company, now occupied as Distribution Engineer. Desires position where there is chance for advancement. C-4171.

ELECTRICAL ENGINEER, 30, married, desires position with public utility, consulting firm, where there is opportunity for advancement. 1½ years General Electric Test; 3 years' experience in design of industrial control apparatus. Wide knowledge of application of control. Excellent references. Location, New York, New Jersey, Southern New England. C-4263.

ELECTRICAL ENGINEER, graduate of London University, with 10 years' practical experience here and in England, at the Westinghouse Lamp Company, N. J., Hazeltine Corporation, N. J., and Vickers, Ltd., England, on production and development work; desires a permanent connection with a large corporation or opportunity to connect with some technical publication. C-846.

APPRAISAL-ELECTRICAL ENGINEER, 29, single. Graduate, three years' experience teaching electrical machinery; six summers in tests, design analysis, transmission, railway shop electrician. Electrician and electrical draftsman fifteen and thirteen months, respectively, in steel mill. Desires work in valuation with a corporation or public service commission. Location, United States. C-4248-1745-Chicago.

GRADUATE ELECTRICAL ENGINEER, 28, single. Experience: one year motor repairing and house wiring, two years layout, estimate and drawing for electrical heating and cooking equipment, one year with large Edison company in New York. Prefers small company where economical estimate, common sense and technical judgment is required in one person. C-4397.

ELECTRICAL ENGINEER, American born, technical graduate, desires position with public utility or industrial concern in middle west. 1½ years construction and maintenance; 1½ years industrial control paper mill; 8 months power plant drafting. C-4428.

SENIOR ELECTRICAL ENGINEER, at Penn State, graduating this June desires a position of opportunity in any commercial or lighting field. Location, immaterial. C-4471.

ENGINEER, to manage, administer, and develop foreign utility properties, 25, graduate Massachusetts Institute of Technology; 4½ years with large central station company: construction, inspection, design of stations; general engineering: operating and construction budgets, cost analyses, interconnection, rates. Location, Europe, North, Central, South America. Salary $3600, with opportunity for advancement. C-4411.

ELECTRICAL ENGINEER, 28, married. Graduate E. E.; on year on specifications of engineering materials; one year testing and development of electrical instruments. Desires permanent position in the Pacific northwest. C-4431.

SENIOR, in Eastern College, taking the electrical engineering course with cooperative training in engineering practice and management, would like position as assistant to chief engineer of small manufacturing concern in the metropolitan area. C-4457.

EXECUTIVE ENGINEER OR MANAGER, 39, married. Lifetime of general utility experience with above average responsibilities. Last five years executive with staff 300 in three-quarter million meter property, developing seven million dollars construction annually. Familiar with all types of problems. Prefer industrial connection affording opportunity of later buying interest. C-3963.

STUDENT, graduating from college with the degree of electrical engineer, and who speaks Spanish and Italian fluently, desires a position with a company doing engineering work in the vicinity of New York City. C-4479.

GRADUATE ELECTRICAL ENGINEER, 22, single, of engineering department of recognized technical college, with year's experience in training course of large utility. Reliable, energetic, good personality. Desires permanent position in maintenance or service department of industrial concern. Location, Philadelphia. C-4480.

TECHNICAL GRADUATE, 23, single. Industrial electrical engineer. Four and a half years' practical experience in substation and generating station operation and maintenance work. Desires connection with public utility or manufacturing concern. Location, east or middle west. C-3909.

ENGINEER, 30, married. Technical graduate in electrical engineering; 3 years' experience with public utility in transmission and distribution department, comprising design as well as intimate public relations; also considerable radio engineering experience. Desires position affording opportunity of more extensive use of training, as well as substantial advancement, dependent upon ability. Location, east. C-1723.

ELECTRICAL ENGINEER, technical graduate, 30. Five years with engineering department of large manufacturer of electric controllers; two years' varied selling experience; one year drafting, central station design. Available on reasonable notice. B-6274.

SENIOR STUDENT at the Cooper Union Institute of Technology; has had a sound training in electrical engineering and three months sales experience and about two years work at radio receivers, testing and assembling department. Would like position in sales department. C-4453.

DEVELOPMENT ENGINEER. B. S. degree electrical engineering; M. S. degree engineering physics. Ten years' experience journeyman electrician, mechanic with large manufacturers and contractors. Past year with very large makers communicating equipment of all kinds as development engineer on magnetic materials. Desires similar position in development of electrical power equipment. Availablee rasonable notice. C-2677.

ELECTRICAL ENGINEER, single 25, B. S., desires permanent connection with opportunity for advancement. Experience: three and one-half years with large rapid transit company, electrical testing, power house and substation operation maintenance. Now engaged, available on short notice. C-4420.

GRADUATE ELECTRICAL ENGINEER, now completing the design of an important power station is available for a new position. Experience includes testing, drafting, construction and supervision of design. Will take responsible charge of electrical plans for steam or hydroelectric project, including estimates, specifications and reports. B-4022.

EXECUTIVE REGISTERED MECHANICAL ELECTRICAL ENGINEER, N. J. and Penn. Massachusetts Institute of Technology, Protestant, American. Engineering statistics, cost reduction and reorganization of industrial factories and power plants: Design; construction; maintenance; steam and water power; fire protection; heating; ventilating; lighting; electric power. Operating costs reduced and factories enlarged without stopping operation. B-5714.

SENIOR in electrical engineering of the graduating class of an eastern college. Desires connection leading to executive or managerial duties. Experience: one-half year Crocker Wheeler motor test and assembly, one year General Electric Test. C-4393.

ELECTRICAL ENGINEER, single, 34, desires position with engineering concern or public utility requiring executive ability. Ten years' experience covering engineering, design, and valuation of power plants, substations, transmission, and distribution lines. Location preferred, East. B-389.

ASSISTANT TO OPERATING SUPERINTENDENT, married, 28. Technical graduate, 15 months Westinghouse course on power and railway work. 2¼ years' computer on new electrification at Cleveland, Ohio. 15 months appraisal engineer on utility in Tennessee. Desires permanent position with future. Location preferred, East or Middle West. C-3997-1659-Chicago.

MECHANICAL ELECTRICAL ENGINEER, married, 48. 25 years' all-round experience as superintendent, production, experimental and designing engineer, and chief draftsman in the manufacturing of small and medium weight electrical and mechanical apparatus and machinery. Last five years with large public utility on powr plant and substation design. Training would qualify for other industrial connection. B-2334.

ELECTRICAL ENGINEER, married, 26. Technical graduate, with five years' experience in switchboard and substation design and construction. C-4504.

ELECTRICAL AND MECHANICAL ENGINEER, 25 years' experience in power plant management, steam engines and Diesel engines; construction and upkeep of wire nets and underground cables; test and repair of electric meters; building and management of power plant batteries; outlaying of interior wiring for large buildings. Location preferred, southwest. Available on short notice. C-4503.

POWER PRODUCTION MAN, married, 32. A successful director of personnel with executive training and a diversified experience of fifteen years in utility operation, including the supervision of interconnected systems, seeks a position as chief operator or assistant to operating manager. C-4501.

ELECTRICAL ENGINEER, 26, single, 1924 graduate. Four years' experience in insulation research in a laboratory of a large concern. Desires a position with a public utility in which there is opportunity for advancement and broad experience. Location, United States preferred. C-4386.

MANUFACTURING EXECUTIVE, American, Christian. Technical graduate experienced in production, development, design and application of small electrical apparatus and instruments. Thoroughly familiar with all manufacturing features in this field such as planning, tool equipment, costs, wage systems, standardization materials and parts, methods and processes for low cost quality products. Sixteen years' experience. B-2721.

ELECTRICAL SUPERINTENDENT, 45, married. Electrical engineering graduate with 15 years' practical experience in construction maintenance and operation of distribution overhead systems; desires position as general superintendent in charge of electrical operation. Location preferred, Northwest. C-4513-85-C-1-San Francisco.

TECHNICAL GRADUATE, 32, married Varied experience including testing, electrical laboratory, substation operation. Five years meter and test engineer large industrial plant. Three years design, calibration and repair with manufacturer electrical instruments. Salary secondary to opportunity. Location, east of Mississippi river. C-4307.

ELECTRICAL AND MECHANICAL ENGINEER, 33, married. S. M., M. I. T. Electrical and mechanical engineering experience manufacturing and consulting work. Six years' teaching electrical and mechanicel engineering. Now head departments of mechanical and electrical engineering in Southern engineering college. Desires position with consulting firm or university, preferably north or east. C-4511.

ELECTRICAL AND MECHANICAL DRAFTSMAN, 28, single, technical graduate with eight years' experience covering design of automotive equipment, fire alarm systems, electric power stations and sales. Desires position with manufacturing, engineering or public utility. Location preferred, United States. C-4510.

ELECTRICAL DESIGNER. Technically trained engineer and draftsman with eleven years' experience on design and checking of electrical layouts for power plants, substations and industrial power and lighting systems. 33. Married. C-292

RADIO TEST AND DEVELOPMENT desired by electrical engineer, 1928 graduate. Major elective in senior year, Radio Engineering. Prior to entering college had five years' radio operating and maintenance experience. First class government license. Desires connection with well established radio company. Salary secondary to opportunity for advancement. Location immaterial. C-4425.

ELECTRICAL ENGINEER, Hindu, 26, single. Technical graduate of American State university; broad, varied experience through graduate student-engineering course, American, big public utility. Two years operation, maintenance, construction steam, hydro power plants. Well acquainted American and Indian languages, customs, politics. Desires position in India with utility or manufacturing company. Indian and American references. C-4355.

SALES MANAGER, 30, married, with M. E. in E. E. degree, available on or before September 1st on thirty days' notice. Eight years' executive engineering experience in public utility, several years' consulting engineering experience and six years sales experience. Now sales manager of large organization. Central or Ohio preferred. B-850.

CHIEF ELECTRICIAN, 28, single, desires position as chief electrican; four years' experience in operation, maintenance and new construction work around industrial plant; also experienced in remote control work; some telephone work, parkway and lead cables and potheads. References as to character and ability to get things done available. Location, immaterial. C-2101.

ELECTRICAL ENGINEER, 34, single. Thoroughly familiar with electrical apparatus for central station and industrial installations. Experienced on connections and wiring for relay protection, metering, etc. Location preferred, New York City. A-5513.

ELECTRICAL ENGINEER, 27, married, E. E. degree, desires position in connection with development of radio receiving and transmitting apparatus. Has had three years' experience in engineering department of large electrical concern with development of transmitting tubes up to largest power. Speaks and writes four languages fluently. Location, immaterial. B-8230.

ELECTRICAL ENGINEER, 29. Four years iron and steel works electrical installation and maintenance; 1 year central station operation; three years oil fields electrical installation and maintenance; 2½ years electrical design of central and substations; three years switchgear and switchboard erection. Location, United States or foreign. C-625.

ELECTRICAL ENGINEER, with eleven years' broad experience in teaching and practical engineering work in manufacturing and public utility companies wishes a professorship in electrical engineering. Holds a master's degree from a recognized eastern university, has been an associate professor for four years and seeks greater opportunities. B-7892.

GRADUATE ELECTRICAL ENGINEER; extensive utility, construction, maintenance and operating experience; design and construction of automatic switching equipment and application to systems. Now with large electrical manufacturing company requiring 30 days' notice, though shorter time may be arranged. Permanent connection with middlewest utility desired. Range of salary, $225-$275 a month. B-3056.

GRADUATE ELECTRICAL ENGINEER, experienced on switching and associated problems. Design and layout of outtdoor and indoor bus and relaying experience. Will go anywhere on thirty days' notice. Utility or manufacturing connection preferred. Salary dependent on possibilities for advancement; $200-$250 per month. C-4519.

GRADUATE ELECTRICAL ENGINEER having eight years' practical experience on transmission, distribution, testing and sales work is desirous of a connection with progressive concern. Willing to accept position abroad. B-7412.

GRADUATE, B. S. in electrical engineering, New Hampshire University, 1928. Honor student; age, 22, single. Some shop experience. Active work preferred. Cannot do heavy lifting. Available, July 1st. Location, United States. C-4517.

ELECTRICAL ENGINEER, 30, married, no children, desires work on hydroelectric construction or operation. Experience: 2 years hydro and 1½ years steam plant operation; 1½ years substation construction; 4 years high head hydro-electric construction. Now chief electrician hydro-electric construction. Expert switchboard wireman. Location, immaterial; Japan or India preferred. C-4482.

TECHNICAL GRADUATE, 29, single, with two years' test floor and four years' Service engineering experience with Westinghouse Electric and Manufacturing Company; desires position with industrial firm or public utility. Best of references. B-8985.

EXECUTIVE, electrical engineer, extensive experience in all departments of utility operation, particularly as property manager, supervisor of power and industrial electric heating sales, difficult negotiations, rates and appraisals, successful record; has good health, personality and appearance; desires position with utility company or consulting engineer. C-3061.

ESTIMATING, ACCOUNTING, APPRAISAL ENGINEER, 27, married. Two years construction work, one year valuation work, Westinghouse graduate course. Well trained in public utility economics and estimating. Prefer engineering economic work in connection with public utility expansion or railway electrification. Location, immaterial. C-3082.

TRANSMISSION LINES: field engineer experienced on all phases of transmission line layout, design and construction. Chief engineer and assistant superintendent. Reading Overbuild. C-4505.

RECENT GRADUATE, B. S. in E. E., 24, single, desires position in research or test laboratory. Two years' experience in radio receiving circuits. Industrious, good personality and has inventive ability. Location, immaterial. C-3213.

EXECUTIVE OR ASSISTANT ELECTRICAL ENGINEER, 44, married. Eight years' power plant and substation design, public utilities; twelve years with consulting engineer, industrial plants, design, specifications, construction supervision, tests, surveys, reports; desires position with consulting engineer, architect, or large industry with number of plants. Location preferred, eastern Pennsylvania. C-4045.

ELECTRICAL ENGINEER, recent technical graduate, desires position with public utility or industrial firm. Has had some practical experience in electrical work. Reliable, industrious, pleasing personality, willing to learn. Does not expect large salary, but desires work that affords good chances for advancement. Location preferred, middle west. C-4534.

GRADUATE ELECTRICAL ENGINEER, varied experience; utility operating; application of circuit breakers, meters and relays; system analysis; layout and design of switching and protection of distribution and transmission systems. Now desires to re-enter operating field with large or medium size utility in the East. Available reasonable notice. Salary required, $250-$300 per month, dependent upon opportunities. C-4533.

ENGINEER, 41. Seventeen years' broad and varied electrical and mechanical trade experience; powerful personality used to obtain results, splendid profit and sales record, strong assets; wishes to be permanently entrusted with the interests of a United States manufacturing concern in Europe. B-8609.

ELECTRICAL ENGINEER, 30, married, technical graduate. Eight years' experience as field engineer with large anthracite coal mining company. Experienced in design, construction and maintenance of electrical equipment. Seeks position with consulting engineering firm or as an electrical engineer with company forming an electrical department. Sales engineering may be considered. Locations preferred, New York or Philadelphia. B-6350.

GRADUATE ELECTRICAL ENGINEER. Desires position with public utility or industrial firm. Two years Westinghouse test; five years electric design of power plants and substations; three years assistant to electrical engineer of industrial firm; five years assistant to superintendent of by-product coke and water gas plant. B-8379.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meetings held May 16 and 24, 1928, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

BARCLAY, ROBERT HAMILTON, Electrical Engineer, Stone & Webster, Inc., Boston, Mass.
BROOKS, HENRY W., Consulting Engineer, 1300 McPherson Bldg., Fremont, Ohio.
ERIKSON, P. E., Assistant European Chief Engineer, International Standard Electric Corp., London, England.
FREDERICK, HALSEY A., Engr. in charge of Transmission Instruments, Bell Telephone Laboratories, New York, N. Y.
GLASSCO, JOHN G., General Manager, Winnipeg Hydro Electric System, Winnipeg, Canada.
LAWRENCE, RALPH R., Prof. of Electrical Machinery, Mass. Inst. of Tech., Cambridge, Mass.
MERRILL, BARRETT M., Supt. of Light and Power, Washington Water Power Co., Spokane, Washington.
MOSSAY, PAUL A., Consulting Electrical Engineer, 200 High Holborn, London, Eng.
RODMAN, WALTER S., Prof. of Electrical Engineering, University of Virginia, University, Va.

To Grade of Member

ALLEN, ASA A., District Engineer, General Electric Co., Dallas, Texas.
BEANE, HARRY E., District Manager, The Bristol Company, Birmingham, Ala.
BORCH, FREDERIK, Engr. in charge of High-Tension Lines and Station Design, Cleveland Electric Illuminating Co., Cleveland, Ohio.
BRAGG, GEORGE H., Engineer of Maintenance, Pacific Gas & Elec. Co., San Francisco, Cal.
BRENTON, WALTER, Assistant Engineer, Portland Electric Power Co., Portland, Oregon.
CHILDERHOSE, ERWIN A., Electrical Engineer, Stone & Webster, Inc., Boston, Mass.
CONLON, WILLARD S., Electrical Engineer, Jackson & Moreland, Boston, Mass.
CONNETTE, THOMAS W., Vice President and General Manager, Lockport Light, Heat & Power Co., Lockport, N. Y.
CURTNER, DAVID L., Assistant Professor of Elec. Engg., Purdue University, Lafayette, Indiana.
DUETSCHER, HARRY O., Electrical Supt., Union Elec. Lt. & Pr. Co., St. Louis, Mo.
EYSTER, JAMES A., Engineer, American Tel. & Tel. Co., New York, N. Y.
FOULKROD, R., Trans. and Protection Engr., Michigan Bell Tel. Co., Detroit, Michigan.
GEORGE, B. JAMES, Industrial Engineer, Kansas City Power & Light Co., Kansas City, Mo.
HELLMAN, MAXWELL P., President, Engert-Hellman, Inc., New York, N. Y.
HEMPHILL, WILLIAM, Asst. Supt. of Distribution, Buffalo General Elec. Co., Buffalo, N. Y.
HERRING, THOMAS F., Sales Engineer, The Bristol Co., Chicago, Ill.
HICKS, LESLIE R., Electrical Engineer, Chas. H. Tenney & Co., Boston, Mass.
HOSAESON, DONALD B., Engr. in charge of Motor Development, Metropolitan Vickers Elec. Co., Manchester, England.
JOHNSON, J. HUGO, Prof. of Elec. Engg., University of Idaho, Moscow, Idaho.
LUFT, OLIVER L., Chief Operator of Substations, Union Elec. Lt. & Pr. Co., St. Louis, Mo.
MALINOWSKI, C. A., Elec. and Mech. Engr., Utah Idaho Central Railroad Co., Ogden, Utah.
McCHESNEY, ROBERT W., Vice-Pres. and Dist. Mgr., Harry Alexander, Inc., Washington, D. C.
MONTGOMERY, WALLACE, Consulting Engineer, Betteravia, Calif.
MORTON, WALTER B., Engineer in charge Electric Design Division, Alabama Power Co., Birmingham, Ala.
NEWELL, HOBART H., Instructor in Elec. Engg., Worcester Polytechnic Institute, Worcester, Mass.
O'BRIEN, BRIAN, Research Physicist, J. N. Adam Hospital, Perrysburg, N. Y.
PEASE, EDGAR R., Wire Chief, N. Y. Telephone Co., New York, N. Y.
QUASS, RALPH L., Telephone Circuit Engineer, Bell Telephone Labs., New York, N. Y.
RING, SAMUEL, Asst. to Engr., N. Y. Edison Co., New York, N. Y.
ROGERS, FRED A., Prof. of Physics and Elec. Engg., Lewis Institute, Chicago, Ill.
SMITH, LYLE W., Elec. Engr., Sargent & Lundy, Chicago, Ill.
STEINKE, JOHN J., Elec. Engr., Henry R. Kent & Co., Rutherford, N. J.
SUMMERS, IVAN H., Elec. Engr., General Elec. Co., Lynn, Mass.
TUCKER, CARLTON E., Asst. Prof. of Elec. Engg., Mass. Inst. of Tech., Cambridge, Mass.
YOUNG, WALTER F., Lapp Insulator Co., LeRoy, N. Y.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a higher grade than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before June 30, 1928.

Armitage, J. W., Hotel Traymore, Atlantic City, N. J.
Ash, N. L., Pennsylvania Pr. & Lt. Co., Allentown, Pa.
Bader, H., Electrical Engineer, 14 Ivy St., Boston, Mass.
Bammes, P. T., Nevada Con. Copper Co., Ruth, Nev.
(Applicant for re-election.)
Beal, J. F., Underwriters Laboratories, Inc., Chicago, Ill.
Benson, F. S., Pacific Gas & Electric Co., San Francisco, Calif.
Benson, W. W., Philadelphia Electric Co., Philadelphia, Pa.
Blair, M. L., Washington Water Power Co., Spokane, Wash.
Blum, M. M., Eastern Offices, Inc., New York, N. Y.
Booze, R. W., Colorado Central Power Co., Golden, Colo.
Bose, C. H., 1230 Union St., Brooklyn, N. Y.
Brown, E. M., Electrical Contractor, Hellertown, Pa.
Browne, R. C., (Fellow, Inventor, Elec. Engr. & Roentgenologist, Salem, Mass.
Burr, H. C., Christian Science Publishing Society, New York, N. Y.
Chafee, C. L., American District Telegraph Co., Columbus, Ohio
Chen, H., 27 East 23rd Street, New York, N. Y.
Clayton, W. B., (Member), General Electric Co., Dallas, Texas
Cornell, E. S., Delta Star Electric Co., Chicago, Ill.
Cutter, C. H., Pacific Electric Mfg. Corp., San Francisco, Calif.
Daniel, T. W., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Day, J. E., Stromberg Electric Co., Toronto, Ont., Can.
Deederly, J. E., Michigan Bell Telephone Co., Grand Rapids, Mich.
Dellert, J. G., Locke Insulator Corp., Philadelphia, Pa.
(Applicant for re-election.)
Drake, O. L., South Penn Collieries Co., Scranton, Pa.
Du Bois, N. W., Northern Light & Power Co., Ltd., Indian Head, Sask., Can.
Duff, C. K., School of Engg., University of Toronto, Toronto, Ont., Can.
(Applicant for re-election.)
Edstrom, N. H., Pennsylvania Power & Light Co., Hazelton, Pa.
Fetzer, J. E., Radio Station WEMC, Berrien Springs, Mich.
Fife, S. T., Speed Scientific School, Univ. of Louisville, Louisville, Ky.
Finley, J. G., Washington Water Power Co., Spokane, Wash.

Fryer, J. J., Century Electric Co., Los Angeles, Calif.
Geddes, G. H., Ohio Brass Co., Mansfield, Ohio
Godfrey, C. M., Chesapeake & Potomac Telephone Co., Washington, D. C.
Gray, A. W., Dielectric Products, Inc., Newport, Del.
Grybek, J., 1575 Alice St., Oakland, Calif.
Hall, F. W., Montreal, Light Heat & Power Cons., Montreal, P. Q., Can.
Hall, R. G., American Tel. & Tel. Co., Chicago, Ill.
Hamrick, G. R., Texas Power & Light Co., Dallas, Texas
Hartley, T. K., American Tel. & Tel. Co., New York, N. Y.
Heafield, G. N., Department of Telephones, Regina, Sask., Can.
Heath, L. W., (Member), Pennsylvania Power & Light Co., Williamsport, Pa.
Hedges, L. B., Bureau of Power & Light, City of Los Angeles, Los Angeles, Calif.
Higgins, L., General Electric Co., Cleveland, Ohio
Hodgkins, W. C., Pacific Gas & Elec. Co., Drum Pr. House, Alta, Calif.
Hodgson, G. O., Edison Lamp Works, G. E. Co., Denver, Colo.
(Applicant for re-election.)
Hopper, A. J., Jr., Connecticut Light & Power Co., Waterbury, Conn.
Howland, W. E., Illinois Power & Light Corp., Hillsboro, Ill.
James, E. A, Pennsylvania Power House & Light Co., Allentown, Pa.
Johnson, A. W., Roller-Smith Co., Bethlehem, Pa.
Judson, C. B., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
(Applicant for re-election.)
Jutson, R. P., Bell Telephone Laboratories, Inc., New York, N. Y.
Kaku, J., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Kennedy, G. F., (Member), Hercules Powder Co., Wilmington, Del.
Kisch, J. P., Public Service Electric & Gas Co., Irvington, N. J.
Langdon, G. G., General Electric Co., Schenectady, N. Y.
Looney, W. C., (Member), Westinghouse Elec. & Mfg. Co., Dallas, Texas
Lueck, I. B., University of Wisconsin, Madison, Wis.
Lupold, J. M., Susquehanna Colleries Co., Lykens, Pa.
McClung, J. C., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
Mills, C. G., Montreal Light, Heat & Power Cons., Montreal, P. Q., Can.
Morrill, L. B., General Electric Co., Boston, Mass.
(Applicant for re-election.)
Moses, J. V., Northwestern Bell Telephone Co., Omaha, Nebr.
Newhard, C. E., Pennsylvania Power & Light Co., Allentown, Pa.
Nicholson, B. J., Westinghouse Elec. & Mfg. Co., Wilkes-Barre, Pa.
Noyes, A. H., California-Oregon Power Co., Grants Pass, Ore.
(Applicant for re-election.)
Nye, I. W.,(Member), Pennsylvania Power & Light Co., Allentown, Pa.
O'Bar, A. S., Dallas Power & Light Co., Dallas, Texas
Osheroff, I., Chas. Mead & Co., New York, N. Y.
Patterson, E. B., (Member), Copperweld Steel Co., Dallas, Texas
Pearson, W. H., (Member), Contractor, Grande Prairie, Alberta, Can.
Reber, J. F., New York Edison Co., New York, N. Y.
Richardson, M. W., Mohawk Carpet Mills, Inc., Amsterdam, N. Y.
Richter, H. G., (Member), Electrad, Inc., New York, N. Y.
Rittershofer, W., Chesapeake & Potomac Telephone Co., Baltimore, Md.
Robinson, R. M., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
(Applicant for re-election.)
Robnett, V. P., Cia Cubana de Electricidad, Havana, Cuba
Roos, W., Mexican Light & Power Co., Mexico, D. F., Mex.
Ross, H. LaF., Otis Elevator Co., Omaha, Nebr.
Rowan, B. J., General Electric Co., Denver, Colo.
Santsizen, C., (Member), General Electric Co., Schenectady, N. Y.
Sasscer, W. H., Philadelphia & Reading Coal & Iron Co., Pottsville, Pa.
Schimmel, H. C., Hammond, La.
Scholz, A. E., Electrical Engineer, Elizabeth, N. J.
Scott, L. J., Consolidated Coal Co., Fairmont, West Va.
Seastone, J. B., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Senn, N. E., Great Western Power Co., San Francisco, Calif.
Silvus, W. E., General Electric Co., Dallas, Texas
Stamm, J. J., Pennsylvania Railroad, Altoona, Pa.
Stanford, A. G., (Member), Robert & Co., Inc., Atlanta, Ga.
Stewart, W. C., General Electric Co., Schenectady, N. Y.
Sullivan, R. J., Westinghouse Elec. & Mfg. Co., Springfield, Mass.
Tate, V. R., Milwaukee Engineering & Mfg. Co., Milwaukee, Wis.
Thomas, C. C., United Gas & Electric Co., New York, N. Y.
Tiffany, A. N., Jr., Borough of Groton Water & Elec. Dept., Groton, Conn.
Tobyn, J. A., Washington Water Power Co., Spokane, Wash.
(Applicant for re-election.)
Vaage, E. F., American Tel. & Tel. Co., New York, N. Y.
Van Guilder, W., (Member), Stewart Warner Speedameter Corp., Chicago, Ill.
Wear, W. J., I. T. E., Circuit Breaker Co., Philadelphia, Pa.
Weaver, C. J., (Member), Consulting Engineer, Waterford, N. Y.
Witherow, H. M., General Electric Co., West Lynn, Mass.
Yanuzzi, C. A. J., Pennsylvania Power & Light Co., Allentown, Pa.
Zobrist, J. H., American Brown Boveri Electric Corp., Camden, N. J.
Total 102.

Foreign

Bhatnagar, R. D., Simla Imperial West Div., Public Works Dept., Simla, India
Cangucu, A., Paulista Railway, Sao Paulo, Brazil, S. A.
Cuthbert, G. T., Public Works Dept., New Zealand Gov't., Tuai, Waikaremoana, Hawkes Bay, N. Z.
Eichberg, F. (Fellow), A. E. G., Berlin, Germany
(Applicant for re-election.)
Gunn, G. J. T., Metropolitan-Vickers Electric Co., Ltd., Trafford Park, Manchester, Eng.
Kotomin, A., (Member), United States Elec. & Pr. Stations of Leningrad, Leningrad, Russia
Newman, F., Shire of Hornsby, Council Chambers, Hornsby, N. S. W., Aust.
Rangachari, T. S., Indian Intitute of Science, Bangalore, India
Simpson, A. V., 28 West Gate, Burnley, Lancashire, Eng.
Stephanus, A. D., (Member), Westinghouse Elec. Int. Co., Oslo, Norway.
Wilkinson, C. D., (Member), Mansfield Colliery, Mansfield, Eng.
Williams, F., British Broadcasting Corp., Cardiff, Eng.
Total 12.

STUDENTS ENROLLED

Amitay, Aaron, Brooklyn Polytechnic Institute
Anderson, Elof, Oregon State College
Andrews, Roy E., Union College
Anthony, Raymond J., University of Pittsburgh
Baker, Leighton S., University of Nebraska
Bassett, Clarence E., University of Maine
Bassett, James C., University of Arkansas
Beasley, R. G., University of Florida
Bector, Nauhria R., University of Iowa
Bedard, Gabriel O., Worcester Polytechnic Inst.
Benesovitz, Abe, University of Minnesota
Benseler, William, The Municipal University of Akron
Bowman, Cornelius P., Virginia Military Institute
Brilmayer, Eugene W., University of Cincinnati
Brotz, Albert J., University of Detroit
Brower, Theron E., Lehigh University
Bruening, John S., Johns Hopkins University
Buchanan, Edward T., McGill University
Burckes, Chandler H., Mass. Institute of Tech.
Chapman, Ned M., University of Utah
Charles, Mario C., Rensselaer Polytechnic Inst.
Christopherson, Arnold J., University of Minn.
Clark, C. Frederick, Iowa State College
Cole, V. Ford, Oklahoma A. & M. College
Cooper, George M., Carnegie Institute of Tech.
Couch, Harvey C., Virginia Military Institute
Coulter, Robert I., California Institute of Tech.
Crandall, Russell K., Stanford University
Cummings, Frederick R., Pennsylvania State College
Cummings, Harold B., Jr., Georgia School of Tech.
Datshkovsky, Joseph, Lewis Institute
Davis, John K., Virginia Military Institute
Decker, Murray T., Virginia Military Institute
Dehus, John E., Engineering School of Milwaukee
DeTata, Charles, University of Colorado
Detwiler, Wilbur F., Engg. School of Milwaukee
Don, David, Oregon State College
Driscoll, John E., Worcester Polytechnic Institute
Ely, F. Winthrop, University of Vermont
Ermish, Lawrence D., South Dakota State School of Mines
Fink, Philip F., University of Nebraska
Fisher, Addison, University of Minnesota
Forbes, Harold E., Georgia School of Technology
Franklin, Samuel H., Jr., Virginia Military Inst.
Freeman, Raymond C., University of Minnesota
Friis, Robert, University of Minnesota
Frutehally, Nazar, Engg. School of Milwaukee
Gardner, Joseph B., University of Cincinnati
Genal, George N., Jr., Engineering School of Milwaukee
Gill, Roscoe L., University of Minnesota
Goode, Louis C., Virginia Military Institute
Goodwin, John S., California Institute of Tech.
Green, Duff, Jr., Virginia Military Institute
Grierson, Cyrus A. W., Mass. Institute of Tech.
Griffin, T., University of North Carolina
Groebli, Robert O., University of Utah
Gwathmey, Lomax, Virginia Military Institute
Hales, George J., Virginia Military Institute
Hallenstein, Nathan A., Rensselaer Polytechnic Institute
Halverson, Vernon E., University of Minnesota
Hanks, Elmer C., Virginia Military Institute
Hanna, Robert C., Virginia Military Institute
Haselwood, Willis E., University of Illinois
Hertel, George M., Engg. School of Milwaukee
Hiltner, Edward B., University of Nebraska
Hite, Glenn O., The Municipal University of Akron
Hobbs, William E., Virginia Military Institute
Hoop, John G., University of Pittsburgh
Horne, John W., Georgia School of Technology
Horton, Elmer G., University of Maine
Hubbard, Cullen P., University of Nebraska
Hurd, Charles P., Newark College of Engineering
Irwin, W. P., Georgia School of Technology
Jamison, Byron C., Purdue University
Jenkins, William F., Rice Institute
Khanna, Mokand Lal, Engg. School of Milwaukee
Knight, Frederick H., Worcester Polytechnic Inst.
Krueger, Walter R., University of Minnesota
Lang, C. Stuart, Iowa State College
Langford, Joseph W., Univ. of New Hampshire

Larson, Maurice C., University of Minnesota
Learned, Robert C., University of New Hampshire
Levy, John L., Clarkson College of Technology
Liu, Maoling, University of Minnesota
Locklin, Robert B., University of Minnesota
Lott, Arwyne O., Georgia School of Technology
Lyons, Walter, McGill University
MacGibbon, Kenneth H., University of Vermont
Mandlebaum, Daniel, Rensselaer Poly. Institute
Massenburg, Walter B., University of North Carolina
Mayer, Francis L., University of Minnesota
McClanahan, William H., Virginia Military Inst.
McCluskey, Emmet J., University of Arkansas
McFall, H. T., Virginia Military Institute
McIlvaine William D., Jr., University of Minn.
Metcalf, Ralph H., University of Wisconsin
Miller, Thomas G., Pennsylvania State College
Mills, Walter T., Stanford University
Mitchell, Wesley L., Rensselaer Polytechnic Inst.
Moore, Leonidas C., University of Florida
Moss, Howard, Virginia Military Institute
Muench, Eugene J., Washington University
Muench, Willard H., Washington University
Novella, Stuart A., Georgia School of Technology
Orrick, Ernest F., Stanford University
Perrenoud, Ernest C., South Dakota State School of Mines
Peterson, Randall J., University of Minnesota
Pettigrew, Albert J., Georgia School of Tech.
Pierce, Norman J., University of New Hampshire
Poschinger, Alfred, Engg. School of Milwaukee
Pratt, Kenneth D., Virginia Military Institute
Pugh, James F., Jr., Virginia Military Institute
Raney, Donald G., University of Minnesota
Relyea, Wilmer D., Stevens Institute of Tech.
Reynolds, Cedric E., Jr., University of Vermont
Rodwell, Charles R., Jr., Virginia Military Inst.
Ross, Lauren C., Purdue University
Rothschild, Henry, University of Kansas
Ruling, F. Charles, Stanford University
Sandretto, Peter C., Purdue University
Savage, Charles F., Jr., Oregon State College
Saxhaug, Erling B., University of Minnesota
Schuetz, Robert F., Cornell University
Seibold, Myron J., Carnegie Institute of Tech.
Seto, Joe N., Harvard University
Shimek, E. Joe, Rice Institute
Shreeve, H. Prescott, Worcester Polytechnic Inst.
Singer, Karl E., State College of Washington
Skinner, Clifton R., Stanford University
Smith, James C., Jr., Virginia Military Institute
Smith, Jay, Jr., Virginia Military Institute
Smith, Levi B., Georgia School of Technology
Specht, James E., University of Minnesota
Spring, Arthur L., Harvard University
Stark, John X., University of Minnesota
Steinberg, Jacob, Brooklyn Polytechnic Institute
Stewart, John P., University of Minnesota
Sulloway, Frank L., University of Vermont
Tidmore, William E., Georgia School of Tech.
Trammell, Robert D., Georgia School of Tech.
Van Blarcom, Robert, Lehigh University
Vatcher, George I., University of New Hampshire
Wagner, Adolph W., Virginia Military Institute
Walczak, Michael J., Rensselaer Polytechnic Inst.
Walker, Charles M., Northeastern University
Waller, Thornton O., Washington University
Weinshank, Leo, Lewis Institute
Wengen, Henry R., Mass. Institute of Technology
Wesson, Holmes C., Jr., Virginia Military Inst.
Whatley, Render L., Georgia School of Tech.
Whitman, John A., Iowa State College
Wightman, John E., Jr., Lehigh University
Wilenzick, Joseph, Georgia School of Technology
Williams, W. Glenn, University of Minnesota
Wilson, Robert E., Jr., Mass. Institute of Tech.
Wilson, William M., Jr., Virginia Military Inst.
Wodicka, Frank, College of the City of New York
Wood, Clyde H., State College of Washington
Wright, Robert A., Virginia Military Institute
Wyse, Lyell S., McGill University
Young, Arden A., Pennsylvania State College
Young, John William, Virginia Military Institute
Youngblood, William C., Jr., Virginia Military Institute
Zaverschnik, Max, University of Illinois
Total 164.

Officers A. I. E. E. 1927-1928

PRESIDENT

(Term expires July 31, 1928)
BANCROFT GHERARDI

JUNIOR PAST PRESIDENTS

(Term expires July 31, 1928) M. I. PUPIN
(Term expires July 31, 1929) C. C. CHESNEY

VICE-PRESIDENTS

(Terms expire July 31, 1928)
H. M. HOBART (District No. 1)
B. G. JAMIESON (District No. 5)
GEORGE L. KNIGHT (District No. 3)
H. H. SCHOOLFIELD (District No. 9)
A. E. BETTIS (District No. 7)

(Terms expire July 31, 1929)
O. J. FERGUSON (District No. 6)
E. R. NORTHMORE (District No. 8)
J. L. BEAVER (District No. 2)
A. B. COOPER (District No. 10)
C. O. BICKELHAUPT (District No. 4)

MANAGERS

(Terms expire July 31, 1928)
JOHN B. WHITEHEAD
J. M. BRYANT
E. B. MERRIAM

(Terms expire July 31, 1929)
M. M. FOWLER
H. A. KIDDER
E. C. STONE

(Terms expire July 31, 1930)
I. E. MOULTROP
H. C. DON CARLOS
F. J. CHESTERMAN

(Terms expire July 31, 1931)
F. C. HANKER
E. B. MEYER
H. P. LIVERSIDGE

NATIONAL TREASURER — **NATIONAL SECRETARY**
(Terms expire July 31, 1928)
GEORGE A. HAMILTON — F. L. HUTCHINSON

HONORARY SECRETARY
RALPH W. POPE

GENERAL COUNSEL
PARKER & AARON
30 Broad Street, New York

PAST PRESIDENTS—1884-1927

*NORVIN GREEN, 1884-5-6.
*FRANKLIN L. POPE, 1886-7.
*T. COMMERFORD MARTIN, 1887-8.
EDWARD WESTON, 1888-9.
ELIHU THOMSON, 1889-90.
*WILLIAM A. ANTHONY, 1890-91.
*ALEXANDER GRAHAM BELL, 1891-2.
FRANK JULIAN SPRAGUE, 1892-3.
*EDWIN J. HOUSTON, 1893-4-5.
*LOUIS DUNCAN, 1895-6-7.
*FRANCIS BACON CROCKER, 1897-8.
A. E. KENNELLY, 1898-1900.
*CARL HERING, 1900-1.
*CHARLES P. STEINMETZ, 1901-2.
CHARLES F. SCOTT, 1902-3.
BION J. ARNOLD, 1903-4.
JOHN W. LIEB, 1904-5.
*SCHUYLER SKAATS WHEELER, 1905-6.
*SAMUEL SHELDON, 1906-7.
*HENRY G. STOTT, 1907-8.
LOUIS A. FERGUSON, 1908-9.
LEWIS B. STILLWELL, 1909-10.
DUGALD C. JACKSON, 1910-11.
GANO DUNN, 1911-12.
RALPH D. MERSHON, 1912-13.
C. O. MAILLOUX, 1913-14.
PAUL M. LINCOLN, 1914-15.
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H. W. BUCK, 1916-17.
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New York	L. W. W. Morrow	J. B. Bassett, General Elec. Co., 120 Broadway, New York, N. Y.
Niagara Frontier	L. E. Imlay	E. P. Harder, 205 Electric Building, Buffalo, N. Y.
Oklahoma	Edwin Kurtz	B. A. Fisher, Oklahoma A. & M College, Stillwater, Okla.
Panama	L. W. Parsons	M. P. Benninger, Box 174, Balboa Heights, C. Z.
Philadelphia	I. M. Stein	R. H. Silbert, 2301 Market St., Philadelphia, Pa.

LIST OF SECTIONS—*Continued*

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Toronto	C. E. Sisson	F. F. Ambuhl, Toronto Hydro-Elec. System, 226 Yonge St., Toronto, Ont., Canada
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Utah	Daniel L. Brundige	C. B. Shipp, General Electric Co., Salt Lake City, Utah
Vancouver	A. C. R. Yuill	J. Teasdale, British Columbia Elec. Railway Co., Vancouver, B. C., Canada
Washington, D. C.	M. G. Lloyd	H. E. Bradley, Potomac Elec. Pr. Co., 14th & C Sts., N. W., Washington, D. C.
Worcester	Guy F. Woodward	F. B. Crosby, Morgan Construction Co., 15 Belmont St., Worcester, Mass.
Total 52		

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Name and Location	Chairman	Secretary	Counselor (Member of Faculty)
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Carnegie Institute of Technology, Pittsburgh, Pa	N. D. Cole	J. H. Ferrick	B. C. Dennison
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Catholic University of America, Washington, D. C	J. V. O'Connor	R. H. Rose	T. J. MacKavanaugh
Cincinnati, University of, Cincinnati, O	C. E. Young	W. C. Osterbrock	W. C. Osterbrock
Clarkson College of Technology, Potsdam, N. Y	G. L. Rogers	J. S. Loomis	A. R. Powers
Clemson Agricultural College, Clemson College, S. C	A. P. Wylie	W. J. Brogdon	S. R. Rhodes
Colorado, University of, Boulder, Colo	J. A. Setter	H. R. Arnold	W. C. DuVall
Colorado State Agricultural College, Fort Collins, Colo	Harold Groat	Howard Steinmetz	H. G. Jordan
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Mississippi Agricultural & Mechancal College, A. & M. College, Miss	H. M. Stainton	R. S. Kersh	L. L. Patterson
Missouri School of Mines & Metallurgy, Rolla, Mo	H. H. Brittingham	E. J. Gregory	I. H. Lovett
Missouri, University of, Columbia, Mo	C. E. Schooley	W. D. Johnson	M. P. Weinbach
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New Hampshire, University of, Durham N. H	N. J. Pierce	M. W. Cummings	L. W. Hitchcock
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New York University, University Heights, New York, N. Y	J. F. Torpie	R. J. Fluskey	J. Loring Arnold
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North Carolina, University of, Chapel Hill, N. C	J. D. McConnell	W. C. Burnett	P. H. Daggett
North Dakota, University of, University Station, Grand Forks, N. D	Alfred Botten	Nels Anderson	D. R. Jenkins
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Ohio Northern University, Ada, O	John Simmons	Verl Jenkins	I. S Campbell
Ohio State University, Columbus, O	R. H. Spry	G. W. Trout	F. C. Caldwell

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Purdue University, Lafayette, Indiana	J. F. Nuner	P. C. Sandretto	A. N. Topping
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Stanford University, Stanford University, Calif.	D. E. Chambers	T. L. Lenzen	T. H. Morgan
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Vermont, University of, Burlington, Vt.	F. L. Sulloway	L. G Cowles	L. P. Dickinson
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Virginia Polytechnic Institute, Blacksburg, Va.	M. B. Cogbill	A. G. Collins	Claudius Lee
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Total 96

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led in the history of
insulated wires and cables.

Kerite is a seasoned
security.

THE KERITE INSULATED WIRE & CABLE COMPANY INC
NEW YORK CHICAGO

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POWER

If you have a power problem and are not satisfied with the results your plant is giving you, it will be to your advantage to consult us.

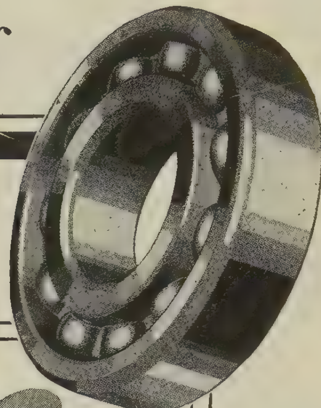
Our services are available for the design and construction of new plants or additions.

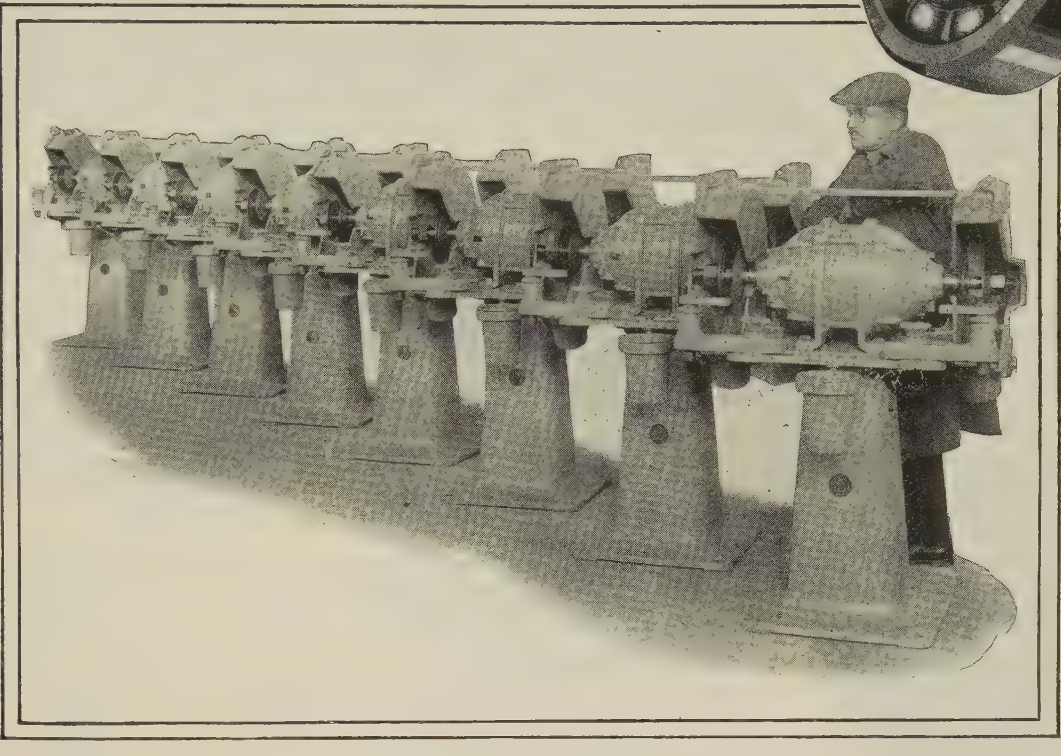
The J. G. White Engineering Corporation

Engineers *Constructors*

43 Exchange Place New York, N. Y.

More than Fifty Manufacturers of General Purpose Motors Use Ball Bearings





886

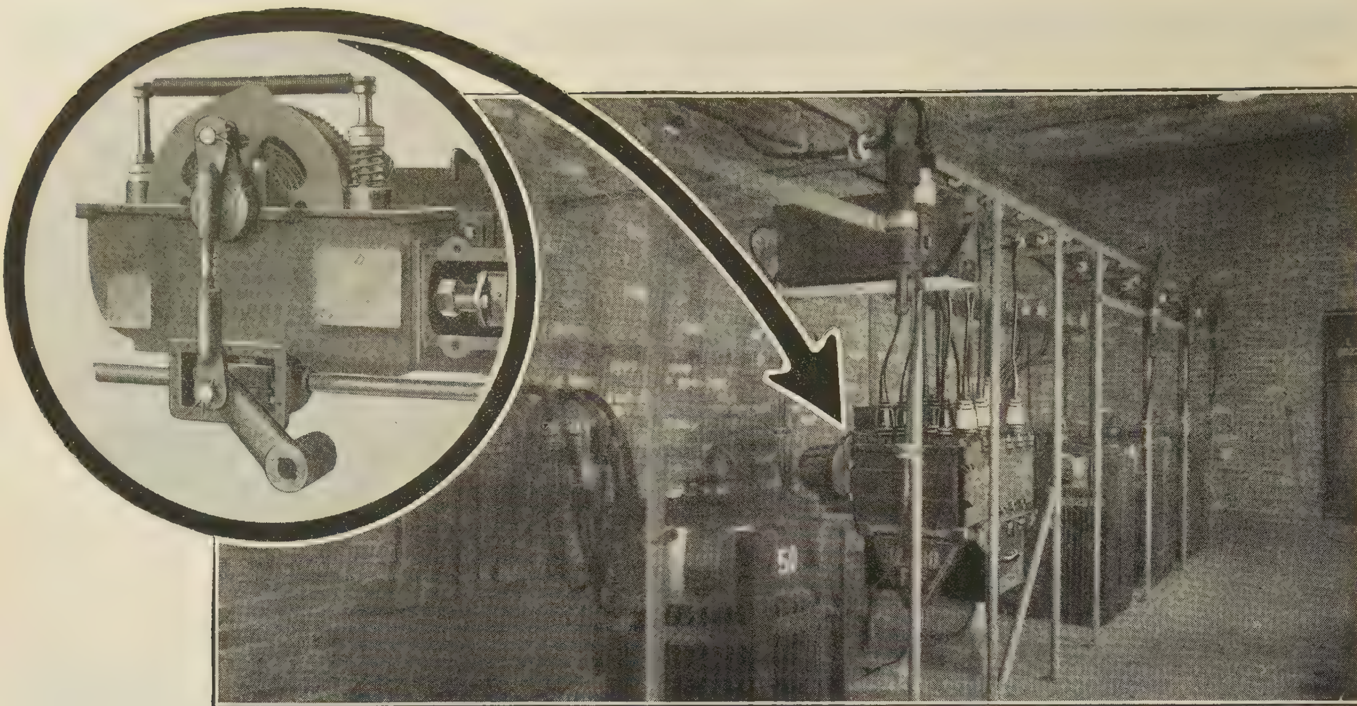
U. S. Electrical Mfg. Company is one of more than fifty electric motor manufacturers who supply a series of general purpose electric motors with ball bearings as standard or optional equipment.

U. S. ELECTRIC MOTORS in these grinders, equipped with New Departure Ball Bearings, were built for the very severe operating conditions found in railroad repair shops.

Such service calls for exceptionally heavy, rugged construction which is materially assisted by the use of ball bearings having not only high capacity to resist heavy loads imposed by grinding machinery but also longest life. Ball bearings are free from measurable wear and the bearing seals remain effective for years, thus keeping motor windings as well as the bearings free from grinding dust.

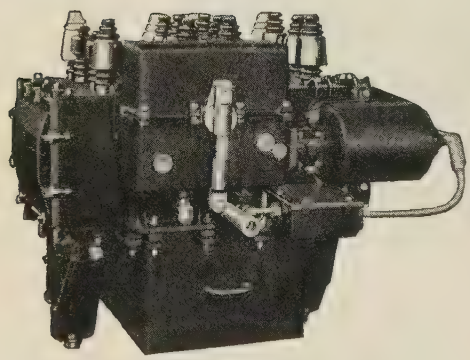
Further reasons why electric motors should be equipped with ball bearings are fully outlined in two booklets published by our Engineering Department. "Booklet K" is of interest to designers. "Cutting Your Cost" is of interest to owners, operators and maintenance men. Either or both sent upon request.

The New Departure Manufacturing Company, Bristol, Connecticut; branches at Chicago, Detroit and San Francisco.



G & W Transformer Vault Unit

Designed to provide main and emergency feeds for an important service or a small underground or overhead district or both.



Vault Unit with automatic throwover used in vault shown above. Immediate throwover to emergency when preferred feed goes dead—delayed return to normal operation after preferred feed is re-energized. No hunting. Minimum outage time.

Either automatic or remote manual or electrical control

THIS development is one of the numerous 1927 G & W accomplishments. It is already in the service of Power Companies for many of their important loads.

Compact 2, 3, or 4 conductor, 200 ampere unit for 4500 volt operation outdoors, in vaults, or in manholes, with provision for automatic and remote manual or electrical throw-over to emergency feed. Built on unit plan. Combines oil-disconnecting switch, two potheads, air break disconnects, and connections to two separate loads. Has air break disconnect on each side of oil switch. The oil switch can be isolated from potential, the feeders can be interconnected, one cable and cable head entirely removed, and each of these reconnected all without any service outage. One transformer or even one entire bank can be disconnected and still permit the other connected transformer to function.

This vault unit is simple and safe to operate and is submersion proof. All live parts are enclosed. Gasketed lids and cover plates are used throughout.

Economical of floor space. Installation costs are low compared with labor costs of installing various separate devices.

Write Us for Suggestions on Layouts.

G & W Electric Specialty Co., 7780 Dante Ave., Chicago

Exactly What You Want

G & W designs and manufactures practically every device for the end of a cable. See our Catalog No. 27.

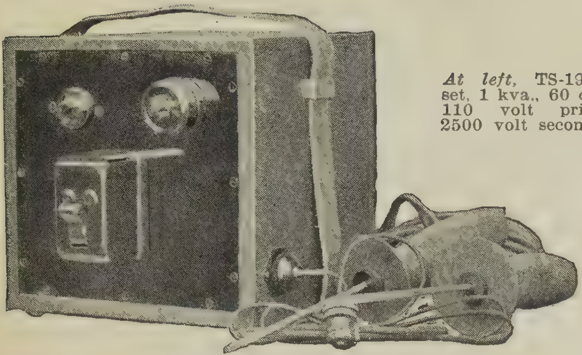
Potheads
Series Cutouts
Primary Cutouts
Oil Fuse Cutouts
Underground Boxes
H&T Insulating Sleeves
Conduit Bells
Ground Pipe Caps
Ground Pipe Points
"Oil and air break" disconnecting devices with and without automatic control
Vault Unit
Oil Disconnect

G&W ELECTRIC SPECIALTIES

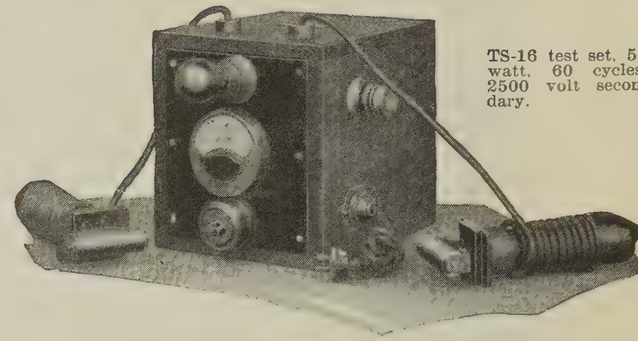
More than Protection G&W for the Cable Ends

POTHEADS AND BOXES

AMERICAN TRANSFORMER

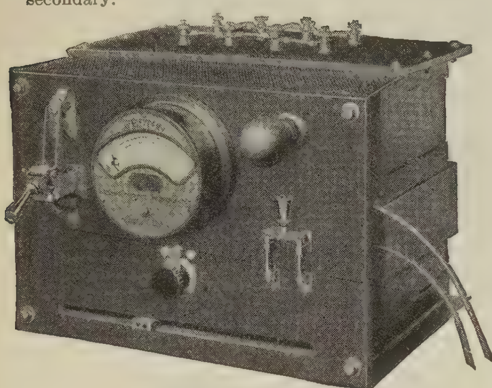


At left, TS-19 test set, 1 kva., 60 cycles, 110 volt primary, 2500 volt secondary.

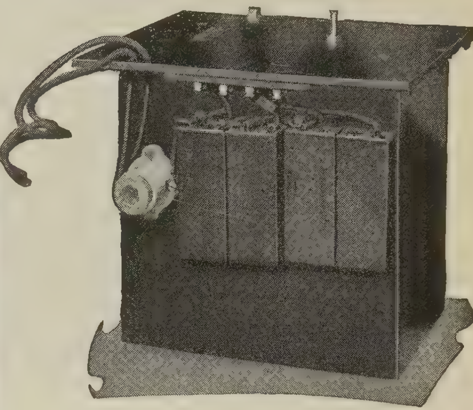


TS-16 test set, 50 watt, 60 cycles, 2500 volt secondary.

Below, TS-15 test set, 1 kva., 60 cycles, 110 volt primary, 3000/6000 / 12,000 volt secondary.

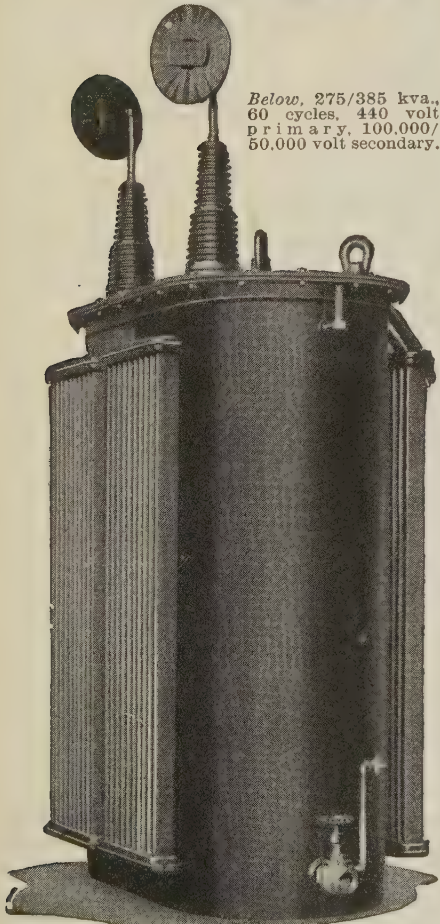


Below, 5 kva., 60 cycles, 110/220 volt primary, 1500 / 3000 volt secondary.

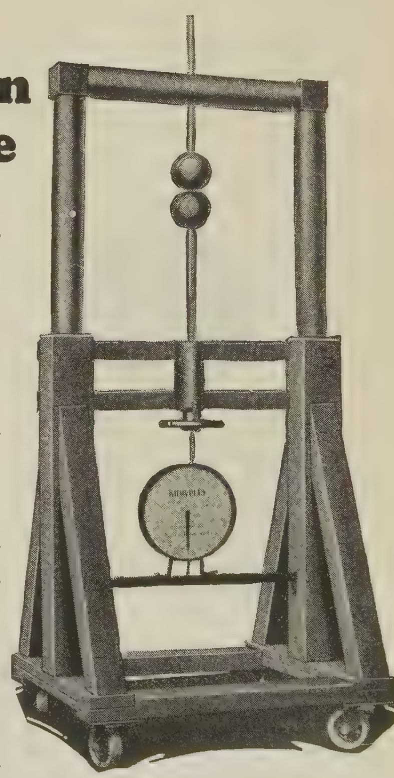


Above, Spark coil rated 50 watts, 60 cycles, 220 volt primary, 10,000 volt secondary.

Below, 275/385 kva., 60 cycles, 440 volt primary, 100,000/50,000 volt secondary.



Spherical spark gap voltmeter for measuring high tension voltage.



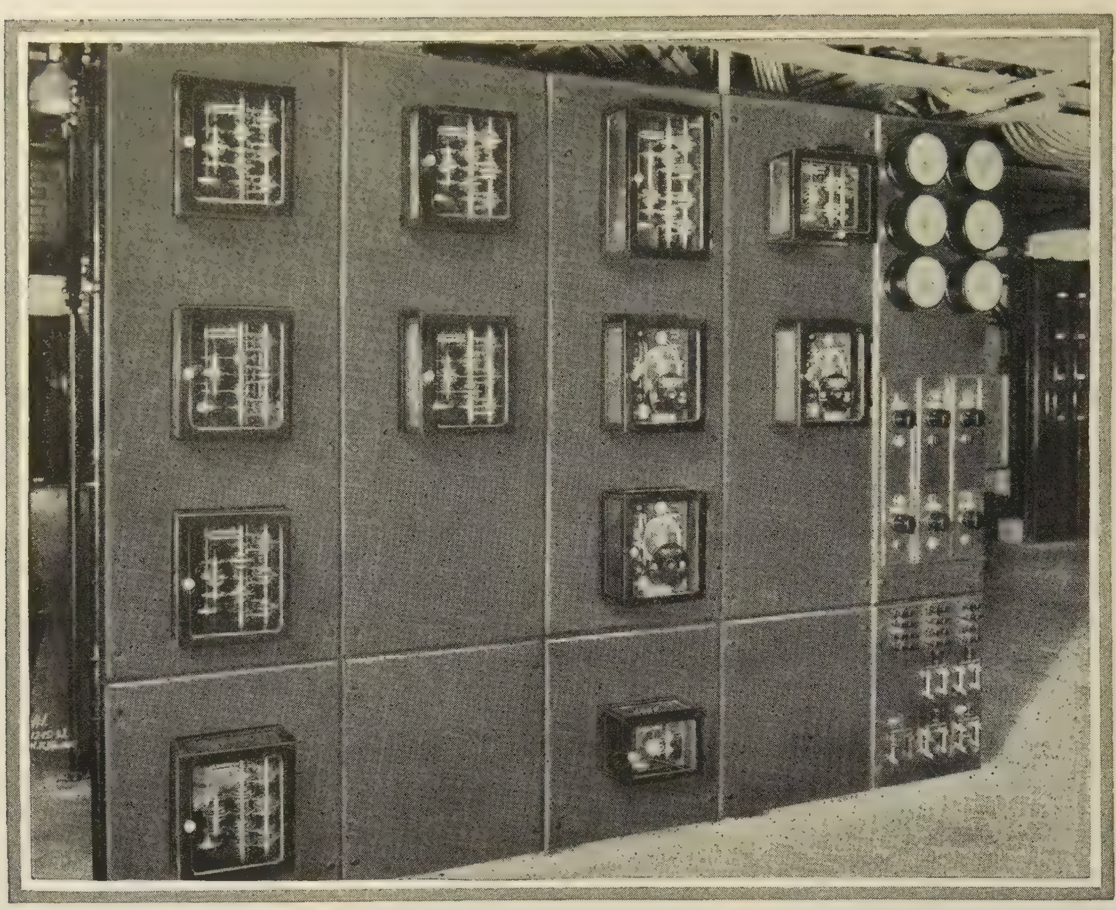
Leading the field in order to keep pace

Keeping pace with central station engineers means to anticipate their wants and then build equipment that they will buy and use.

During the past year, central station leaders have purchased these special testing sets and equipment indicating that American Transformer leadership is still being maintained. The units illustrated are included in our new Bulletin 1110-J, which describes fully all the latest testing sets and special equipment for meeting present day problems.

AMERICAN TRANSFORMER CO.

176 Emmet Street, Newark, N.J.



Where the demand of 48 circuits will be totalized and recorded

This board is equipped with G-E totalizing relays (Type DT) to totalize the energy carried by 36 circuits. One G-E demand meter (Type PD) records the totalized demand. The ultimate installation will accommodate 48 of these circuits—submarine cables from the Cahokia Station, Union Electric Light & Power Company of Illinois, to distribution substations in the city of St. Louis, Mo.

The 48-circuit installation will include eight 6-circuit relays, each of which totalizes the impulses from six watthour meters. The impulses from these eight 6-circuit relays are in turn totalized by one 8-circuit relay, or master totalizer. The impulses from this 8-circuit relay operate the demand meter, which records the totalized demand of the 48 circuits.

This solution of a complex demand-metering problem is of interest because of the increasing number of situations where this type of equipment has become necessary.

In addition, the G-E equipment, shown above, includes G-E relays and demand meters for totalizing the entire station output.

Type DT relays, used in conjunction with the PD demand meter, make it possible to measure the total demand of practically any number of circuits. Discuss their application with G-E representatives. Described in bulletin GEA-716A.

620-7

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN PRINCIPAL CITIES

MINERALLAC CABLE-PULLING COMPOUND No. 150

A Compound for Pulling Cable Through Underground Ducts

A better lubricant—decreasing the pull necessary on the cable, and forestalling the possibility of stretching and damaging the sheath and insulation.

Being a better lubricant, it speeds up the work.

Adheres to the cable on the way in, lubricating the entire length of duct.

Does not deteriorate with age. The duct is still lubricated when the cable comes out.

It is cheaper. The increased cost per pound is more than offset by the small amount necessary for complete lubrication.

It is harmless to the cable, being chemically inactive.

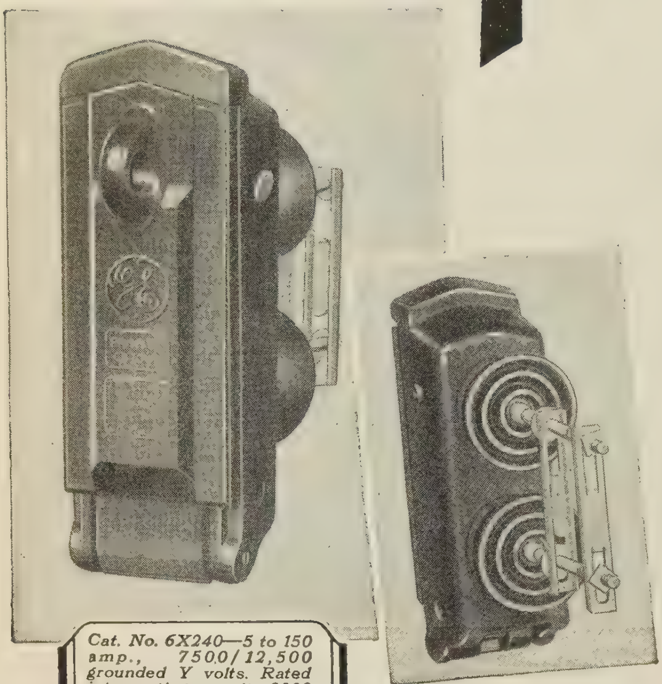
Cleaner and more healthful—it does not blow all over the street.

The ideal lubricant—you can put it on with a brush.

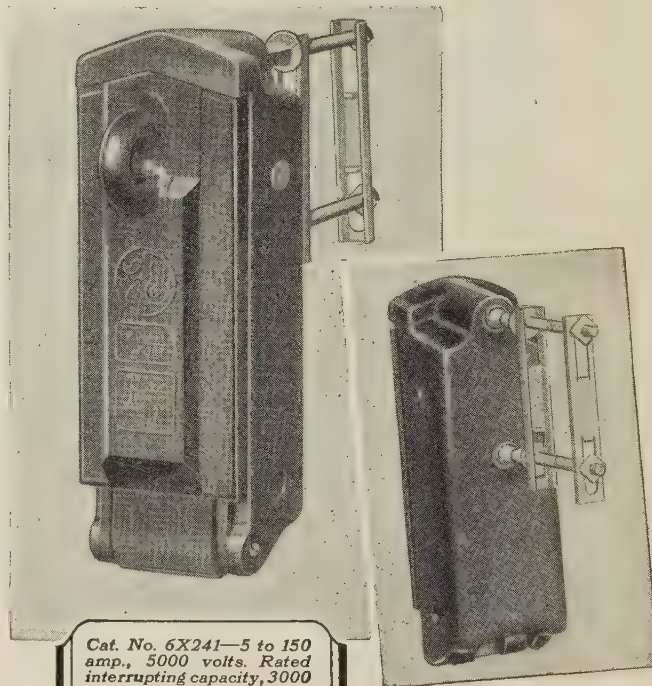
Minerallac Electric Company

CHICAGO, ILLINOIS

The 4 new G-E

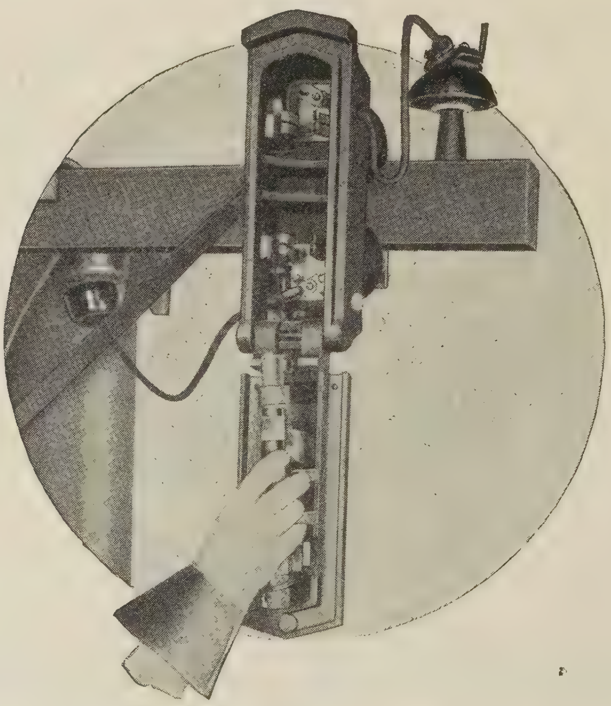


Cat. No. 6X240—5 to 150 amp., 7500/12,500 grounded Y volts. Rated interrupting capacity, 3000 amp., at 60 cycles.



Cat. No. 6X241—5 to 150 amp., 5000 volts. Rated interrupting capacity, 3000 amp., at 60 cycles.

To make improvements so outstanding as those embodied in this new group of G-E cutouts, three things were indispensable: exceptional equipment, many years of experience, and the desire to achieve perfection. G-E cutout engineers work unremittingly, guided by a wealth of experience, and secure in the knowledge that they will not lack necessary facilities. Each new advance brings them nearer to the goal for which they are striving—a perfect cutout.

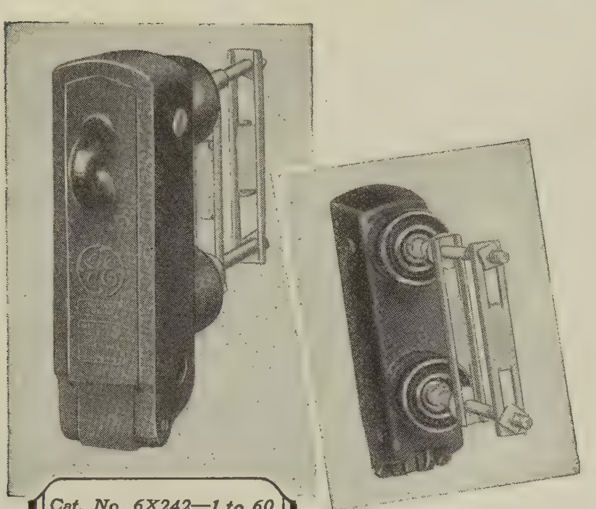


Cat. No. 6X240 cutout opened.

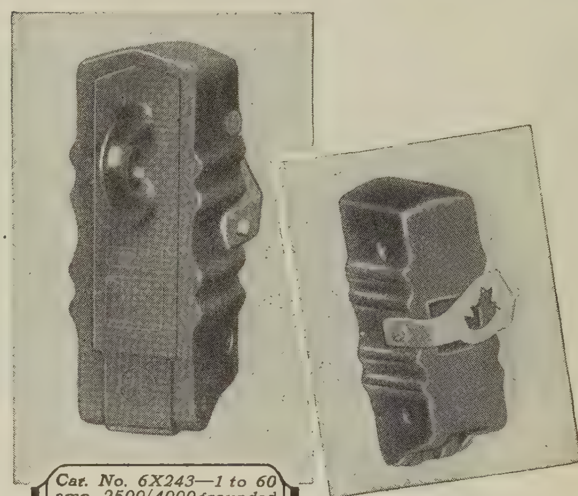
GENERAL

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Cutouts — a new standard



Cat. No. 6X242—1 to 60 amp., 7500 volts. Rated interrupting capacity, 1500 amp at 60 cycles.



Car. No. 6X243—1 to 60 amp., 2500/4000 grounded Y volts. Rated interrupting capacity, 1500 amp., at 60 cycles.

Increased Insulation
Increased Current Ratings
Increased Interrupting Capacities

These G-E cutouts meet the operating requirements of modern distribution systems. The new ratings were scientifically established by a careful investigation of system voltages, modern practice in line insulation, capacities of transformers installed, and possible short-circuit currents.

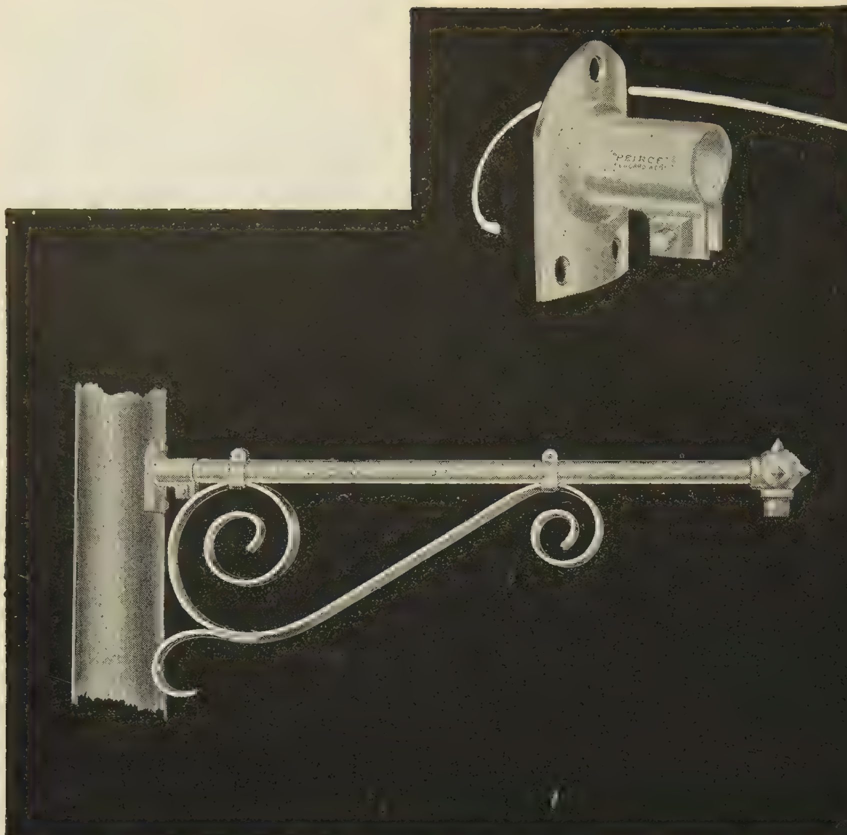
Operators of the lower-voltage systems can now use high-grade cutouts economically without being penalized with costs of equipment designed for higher-voltage systems. In the design of the cutouts for higher-voltage systems, no compromise in quality has been made to obtain lower costs, but the design affords full insulation in accordance with the service required.

For complete description, see Bulletin GEA-969.

420-13

ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES



This PEIRCE pressed steel pole plate..

Stronger than castings
Clamps the bracket
Permits internal wiring
Curved to fit the pole

Build Strength, Economy and Beauty into your Street Lighting Systems—Use

PEIRCE STREET HOOD BRACKETS

Now is the time to consider your street lighting program. Street Lighting Engineers are working up their specifications with the idea of building *strength*, *economy* and *beauty* into their lighting systems.

The Peirce Straight Arm Type Street Hood Brackets have been designed by our engineers with this idea in mind. *Strength*—they are far superior in strength to other types of street hood brackets due to the fact that they are mounted to the pole by presteel pole plates rather than castings. *Economy*—they are cheaper in the long run than the ordinary type of bracket due to the fact that they are completely galvanized by the Hubbard Hot Double-Dip Process. *Beauty*—they are made with an artistic scroll and take up less space on the pole than most other types of street hood brackets.

The Peirce Presteel Pole Plate which is a part of these brackets is a new departure in the street lighting field and has been prompted by many accidents occurring to linemen who often accidently drop to the street on account of defective castings. For this reason Peirce has developed a Pole Plate of presteel, stronger than castings, which eliminates threads on the pole end of the bracket and clamps around the pipe.

for COMPLETE LISTING of this PEIRCE SPECIALTY Refer to the HUBBARD CATALOG

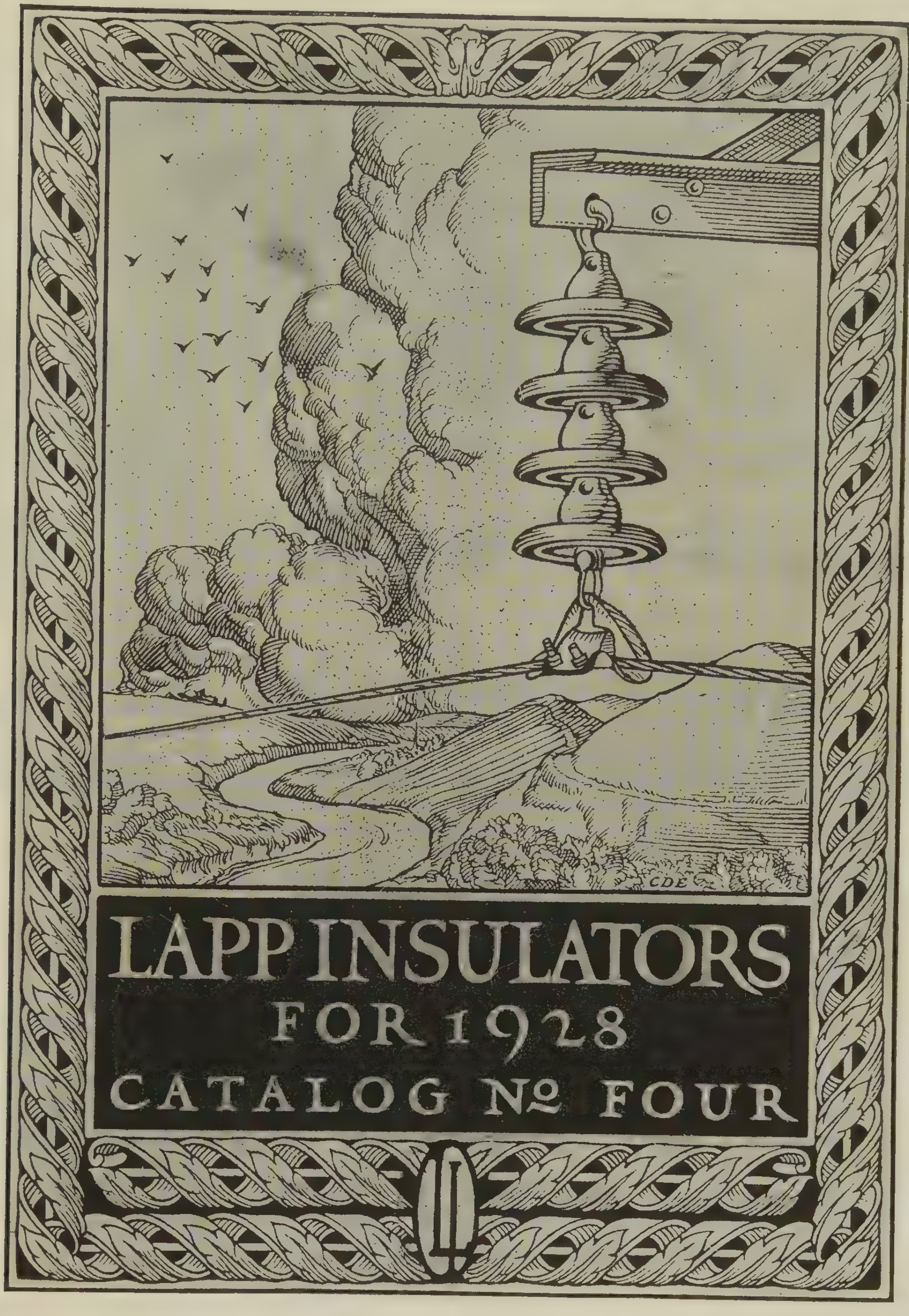
Hubbard Pole Line Hardware, Peirce Construction Specialties and Copperweld Ground Rods are carried in stock and sold exclusively through the leading Electrical Jobbers.

— There is one near you —

Hubbard and COMPANY

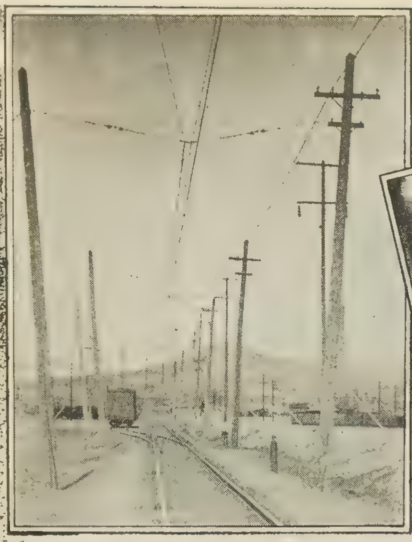
HUBBARD

PITTSBURGH · OAKLAND, CAL. · CHICAGO

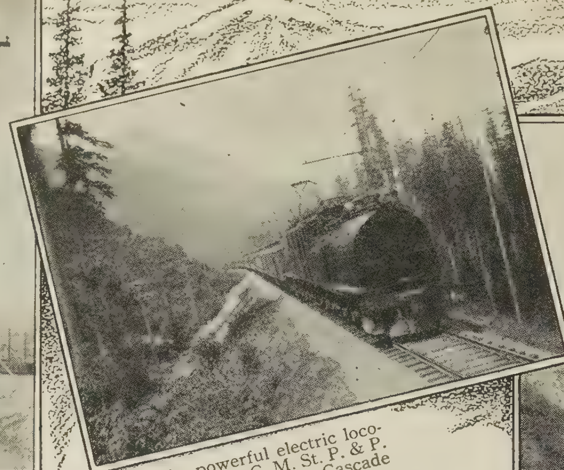


NEW Lapp Catalog No. 4 should be in hands of all executives and engineers handling transmission. It is unusually complete. New Lapp Fog Type pin and suspension insulators are included. These are solving dirty insulator troubles right and left. Also complete section of commercial radio insulators; new clamps; real information as to porcelain production; design data curves which engineers will value.

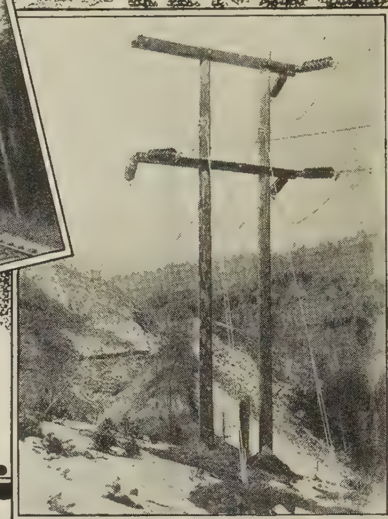
LAPP INSULATOR CO., INC., LeRoy, N. Y.



Illustrating the overhead construction on the C. M. St. P. & P. Railroad, O-B catenary materials in use.



One of the powerful electric locomotives pulling a C. M. St. P. & P. passenger train over the Cascade Range.



The 100-kv. transmission line illustrating the extensive and strenuous use made of O-B suspension insulators.

640 Miles Over the Rockies and Cascades to the Pacific

LATE in 1915, the first train drawn by an electric locomotive on the Chicago, Milwaukee, St. Paul & Pacific Railroad, pulled out of Butte, Montana for its initial trip over the Continental Divide.

More than twelve years have passed since then, but this electrification project still remains one of the outstanding engineering achievements of the century. Penetrating the rock-bound barriers of the Rockies, where but a generation before, the ox-drawn Red River wagons of the pioneers struggled; through the vast and lonely forests of the Bitter Root Mountains; over the sand and wind-swept prairies of the Columbia River Basin; down the fertile Kittitas Valley; through miles of tunnels and finally over the snow-bound heights of the Cascade Range to the evergreen fields of the Pacific Coast, these silent Moguls—these giant locomotives now speed.

Over 500 miles of 100-kv. transmission line carries power to these massive locomotives. The erection of this line alone was a task of almost unsurmountable difficulty. Yet despite the strains and stresses placed upon them, where 1200-ft. spans are not unusual, the 155,000 O-B suspension insulators used have given unequalled service and maintenance of the line has thus been simplified. According to engineers of this great railway, there is not one record of a failure of service which can be attributed to O-B insulators.

Such a record, extending over a period of thirteen years and involving a wide range and variety of climatic conditions, can well serve as a sound guide in selecting insulators for your future electrical developments.

Ohio Brass Company, Mansfield, Ohio
Canadian Ohio Brass Co., Limited
Niagara Falls, Canada
854H

Ohio Brass Co.

NEW YORK CHICAGO PHILADELPHIA PITTSBURGH ATLANTA CLEVELAND ST. LOUIS SAN FRANCISCO LOS ANGELES

PORCELAIN INSULATORS
LINE MATERIALS
RAIL BONDS
CAR EQUIPMENT
MINING MATERIALS
VALVES

Matthews Scrulix Anchors are best for most anchoring needs, but—

If You Prefer

An Expanding Anchor— Here's A Better One

IN tests and in use, engineers and linemen are finding Matthews Xpandix Anchors superior to any anchor of this type on the market.

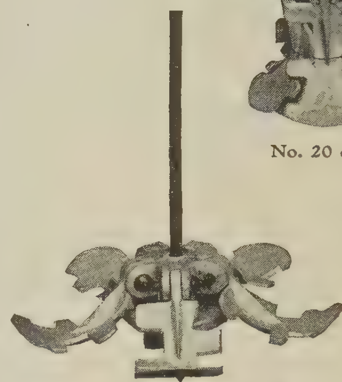
They are the fastest expanding anchor, due to design. The expanding arms push on the expanding blades from the *inside* out and not from the outside out. The blades have a sharp edge all the way around. There are no projections on the blades to cause resistance. Rods can always be recovered when desirable to abandon the anchor. Made of certified malleable iron.

In a recent test in sandy ground three Number Eights held an average of over 16,000 lbs., breaking rod in each case. Average creepage at 10,000 lbs., 0.44 inch. In the same sandy ground three Number Twentys held an average of over 27,000 lbs. before coming out and 50,000 lbs. strain was required to pull out the Number Twenty installed six feet in yellow clay.

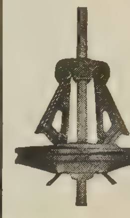
Note trial offer below. The Number 6 is recommended for use with 6,000 lb. guy strand, Number 8 for use with 10,000 lb. guy strand and Number 20 for use with 16,000 lb. guy strand.

W. N. MATTHEWS CORPORATION
Engineers and Manufacturers
3706 Forest Park Blvd., St. Louis, Mo., U. S. A.
Your nearest Electrical Distributer will serve you on Matthews Specialties

No. 20 closed

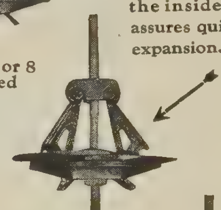


No. 20 expanded



No. 6 or 8 closed

Note action of the expanding arms. The *push* is from the inside out which assures quicker, easier expansion.



No. 6 or 8 partially open

No. 6 or 8 entirely open

Trial Offer

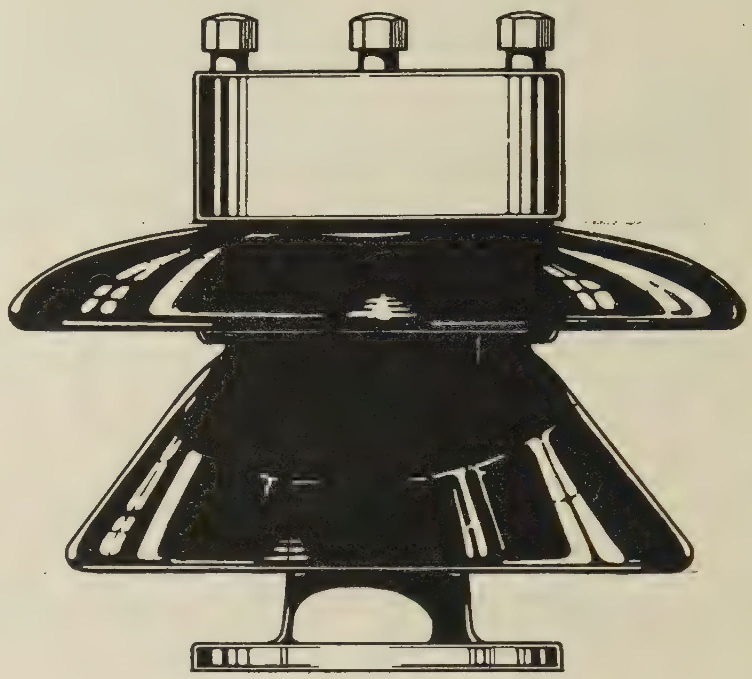
Twelve or more Matthews Xpandix Anchors (all of one size or assorted) will be shipped on thirty (30) days trial, freight charges prepaid on the *initial* order. If these anchors prove satisfactory, you pay our bill; otherwise ship them back freight charges collect and bill will be cancelled for those returned.

W. N. MATTHEWS CORPORATION ST. LOUIS U.S.A. ESTABLISHED 1899

MATTHEWS
XPANDIX
ANCHORS

144

When service counts



LOCKE 8888

Maximum characteristics with minimum space requirements.

Locke switch type insulators are known and used everywhere.

Locke 8888 was developed for use where high electrical values, and medium high mechanical strength were necessary within a decidedly limited area. Today it has been adopted as standard on many of the largest systems.

When you specify Locke Porcelain for your switches, you are specifying maximum satisfactory performance.

All your insulator needs, whether on the line or in the station, can be filled with Locke Porcelain.

specify

LOCKE PORCELAIN INSULATORS

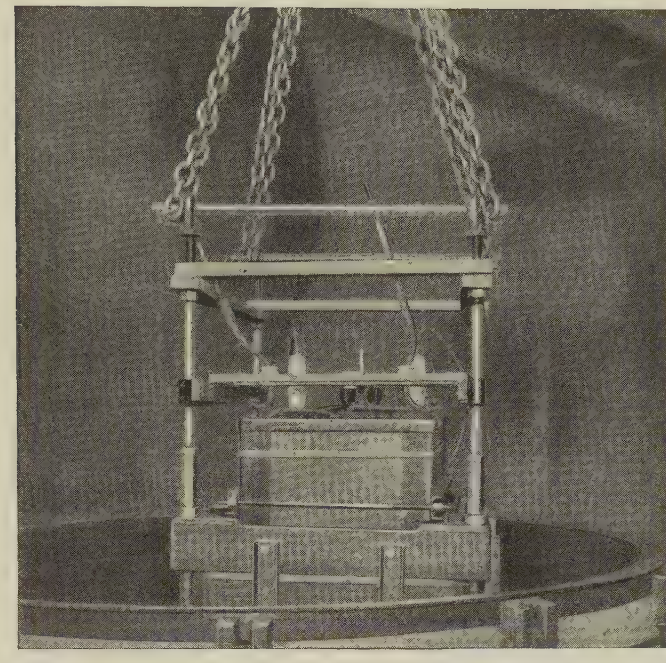
LOCKE INSULATOR CORPORATION

BALTIMORE MARYLAND

PRODUCTS

MOTORS...Single-phase, Polyphase and Fynn-Weichsel Motors **TRANSFORMERS...Power, Distribution and Instrument**

FANS...Desk, Wall and Ceiling types



Wagner Vacuum Drying Tank. Power Transformer elements are dried at 100 degrees centigrade, vacuum 28 inches

Wagner Quality

"*Megger*" must read "*Infinity*"

ALL Wagner Power Transformers are dried in a vacuum tank at a temperature of 100 degrees centigrade under 28 inches of vacuum. Insulated terminals are brought out through the side of the tank for measuring the insulation resistance and drying is continued until the "megger" shows a reading of infinity. Dry transformer oil then admitted to the tank submerges the core and coils. This treatment insures a bone dry element which when removed from the vacuum tank is immediately placed in its own case and covered with oil.

The final assembly operations are completed so quickly that the coils and insulation cannot absorb moisture.

Precautions such as these, combined with many refinements of design, make Wagner Power Transformers a well paying investment.

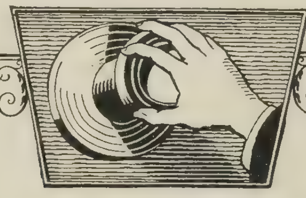
Ask for Bulletin 140

WAGNER ELECTRIC CORPORATION...6400 Plymouth Avenue...St. Louis, U.S.A.

20-6737-17

HERE MR. SECRETARY IS THE ANSWER OF ONE INDUSTRY

No. 3 of a series inspired by the report of Secretary Hoover's Committee On Elimination of Waste.



A STEADY HAND AT THE CONTROLS

In manufacturing the nation's telephones Western Electric must make more than 110,000 different kinds of parts, assemble them into thousands of apparatus units, and build these units into the operating communicating system.

A manufacturing activity of such proportions would involve the danger of extensive waste were the program of production not so thoroughly co-ordinated.

Western Electric has made substantial progress in the solution of this problem by the application of an accurate schedule system to every phase of the complicated operations, from purchase of raw material, through process of manufacture, and on through distribution to customer. Moreover, where outside sources of supply of partially fabricated materials have proven inadequate or unreliable it has created as a part of itself a group of related industries.

Sure-handed control enables this Company to deliver its wide range of output when needed thus eliminating the wastes of uncontrolled production.

Western Electric

Purchasers... Manufacturers... Distributors

SINCE 1882 FOR THE BELL SYSTEM

The One OVERHEAD GROUND WIRE

with a PERMANENT SAFETY-FACTOR

Modern Transmission Lines Need Permanence

WHEN new, any overhead ground wire may have ample safety. Is that safety retained year after year?

Is *rusting* constantly reducing the safety-factor?—or does *lack of* ruggedness hasten the day of replacement?

PLAY SAFE—install the Overhead Ground Wire which permanently keeps the safety-factor it has when new.

"COPPERWELD" Overhead Ground Strand is *permanent*—because

It is RUGGED—a thick exterior layer of tough, ductile *copper* on *each separate wire* is molten-welded to its steel core.

It is STABLE—the steel core in each separate wire is high strength, high elastic limit, *heat-treated—tenacious.*

It is NON-RUSTING THROUGHOUT—each and every wire has *its own self protection* from rusting—each and every wire touches *one metal only, copper*—no rusting, no pitting, no electro-galvanic deterioration.

Turn the page for Design Recommendations →

"COPPERWELD" SAFE RUGGED

AN OPEN LETTER

to Transmission Line Engineers on OVERHEAD GROUND LINES . .

with 5 Recommendations on Design . . .

Recommendation No. 1—Make the Overhead Ground Wire *about 10% safer* than the Power Conductors used on the same structure. When a factor of safety of 2.00 is used for the Power Conductors, use a factor of about 2.25 for the Overhead Ground Wire. Take no chances on the Overhead Ground Wire breaking in times of heavy ice loading. Design the ground wire to improve service and insure continuity of service under all conditions.

Recommendation No. 2—String the Overhead Ground Wire with less sag than the Power Conductors, so that with unequal ice or wind loading ample clearance will always be maintained at middle of span. Stringing the ground wire with less sag so that even with ice on the ground wire and none on the conductors there is no danger of the wires coming in contact at the middle of the span.

Recommendation No. 3—Use a higher tensile strength material for the overhead ground wire than for the Power Conductor. A smaller diameter can then be used at less cost and it may be strung at less sag and with a greater factor of safety.

Recommendation No. 4—Whether you suspend the Overhead Ground Wire on *Flexible* or *Rigid* supports (you may use *either* method *safely* with Copperweld Strand) — use only the best designs of clamp.

Recommendation No. 5—Ask the Engineering Department of the Copperweld Steel Company for recommendations on wires, clamps, etc., on each Overhead Ground Wire problem you may have—their experience and assistance may prove invaluable to you, and you will not be at all obligated.

Copperweld Steel Company

MAIN OFFICE & MILLS—GLASSPORT, PENNA.

New York, 30 Church St. Chicago, 129 S. Jefferson St.
Dallas, 823 S. Edgefield St. San Francisco, Rialto Bldg.

Northern Electric Co., Ltd.
Main Offices, Montreal, Canada

© 1928 by Copperweld Steel Company, Glassport, Pa.

"COPPERWELD"

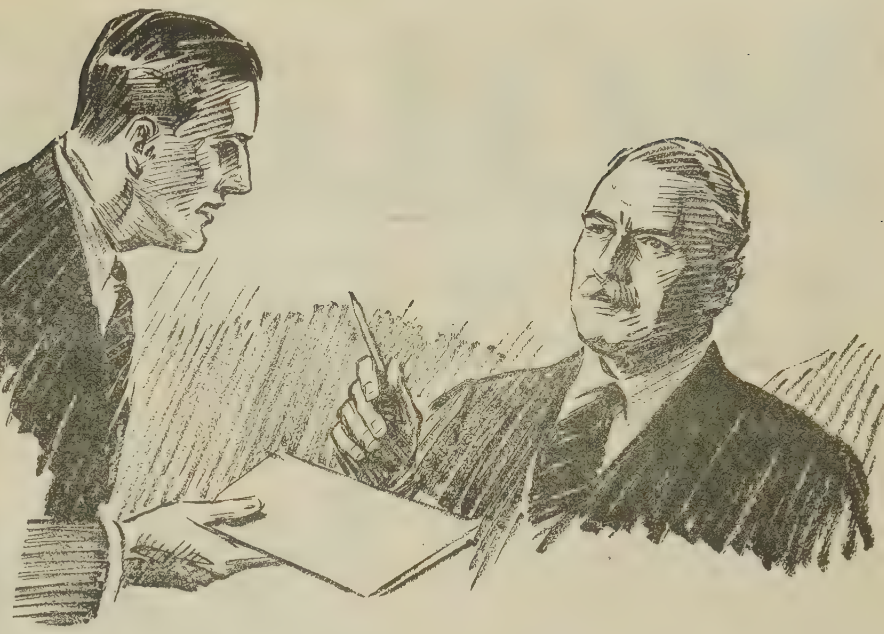
OVERHEAD GROUND WIRE

COPPERWELD STEEL COMPANY
Glassport, Penna.

I am interested in overhead ground wires that are permanently safe. Please send Engineering Data on Overhead Ground Wires.

Name________ Title________
Company________
Street________ City________ State________

RUGGED SAFE PERMANENT



What!

New equipment again?

"WHAT'S the matter with our connecting devices? We've had more failures on clips and clamps and turnbuckles than we've had on the line itself. What's wrong, Mr. Simpson?"

"The metal is wrong, Mr. White. We've been using steel, and on that strip of seacoast line it corrodes pretty fast. It's worst of all on the connectors where the steel comes in contact with copper. You see, the salt air makes a good electrolyte, and the copper, being negative, acts on the positive steel, causing it to deteriorate."

"Is this only along the seashore? It seems to me we have a lot of replacement work on connecting equipment on all our transmission lines."

"We do. Normal steel corrosion takes place anywhere, but the galvanic action is worst in salt air."

"Well, if steel corrodes so badly, why don't we use some other metal that is as strong as steel and still will not become weakened by exposure?"

Mr. White, without knowing it, has described EVERDUR, the metal which is produced in the very equipment needed to cut down maintenance costs.

Everdur is a copper, manganese, silicon alloy possessing high strength and high fatigue limit. It offers great resistance to corrosion and wear. It is non-magnetic, and does not set up electrolysis when in contact with copper. It can be machined, cast, pressed, forged, welded, cut and brazed. It is readily available in the form of plates, sheets, rods, wire, pipe, hot pressed parts, forging blanks and casting ingots—and fabricators are prepared to furnish nuts, bolts, rivets, lock washers and castings. Everdur is exclusively an Anaconda alloy.

EVERDUR
Reg. U. S. Pat. Off.

For further information on Everdur, please write for Anaconda publication E-2., Second Edition.

THE AMERICAN BRASS COMPANY
GENERAL OFFICES: WATERBURY, CONNECTICUT
Offices and Agencies in Principal Cities
Canadian Mill: ANACONDA AMERICAN BRASS LIMITED
New Toronto, Ontario

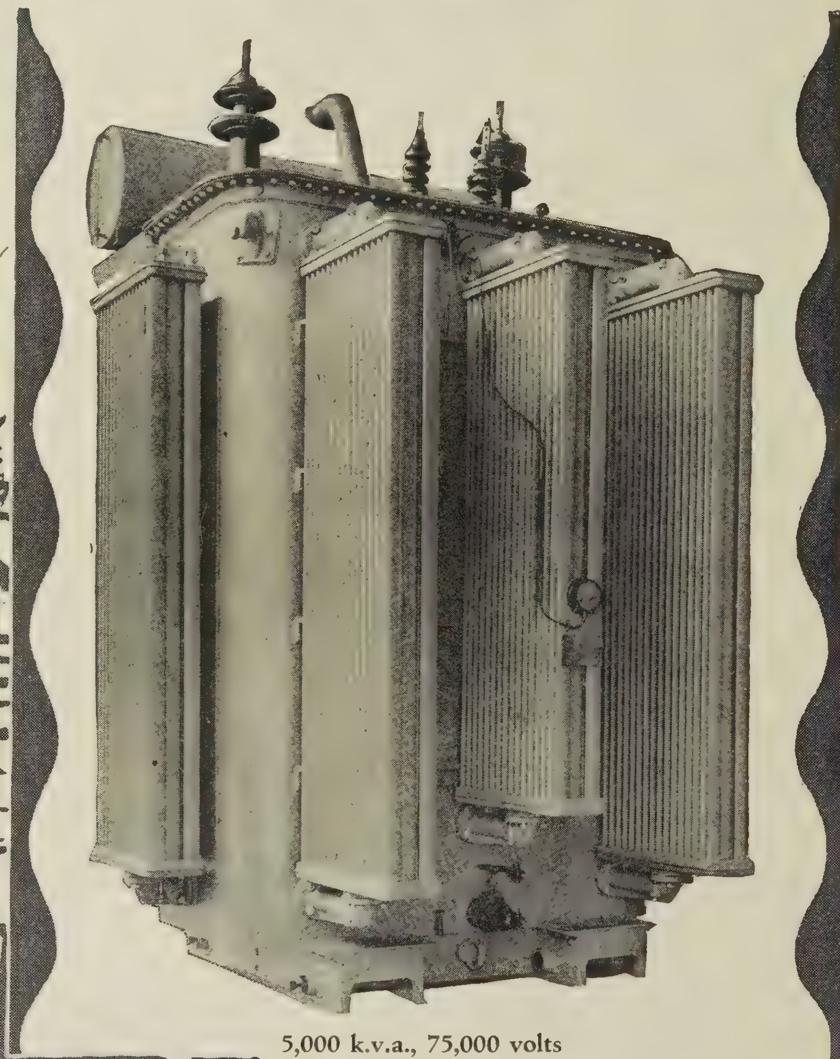
ANACONDA COPPER

BRASS ANACONDA BRONZE

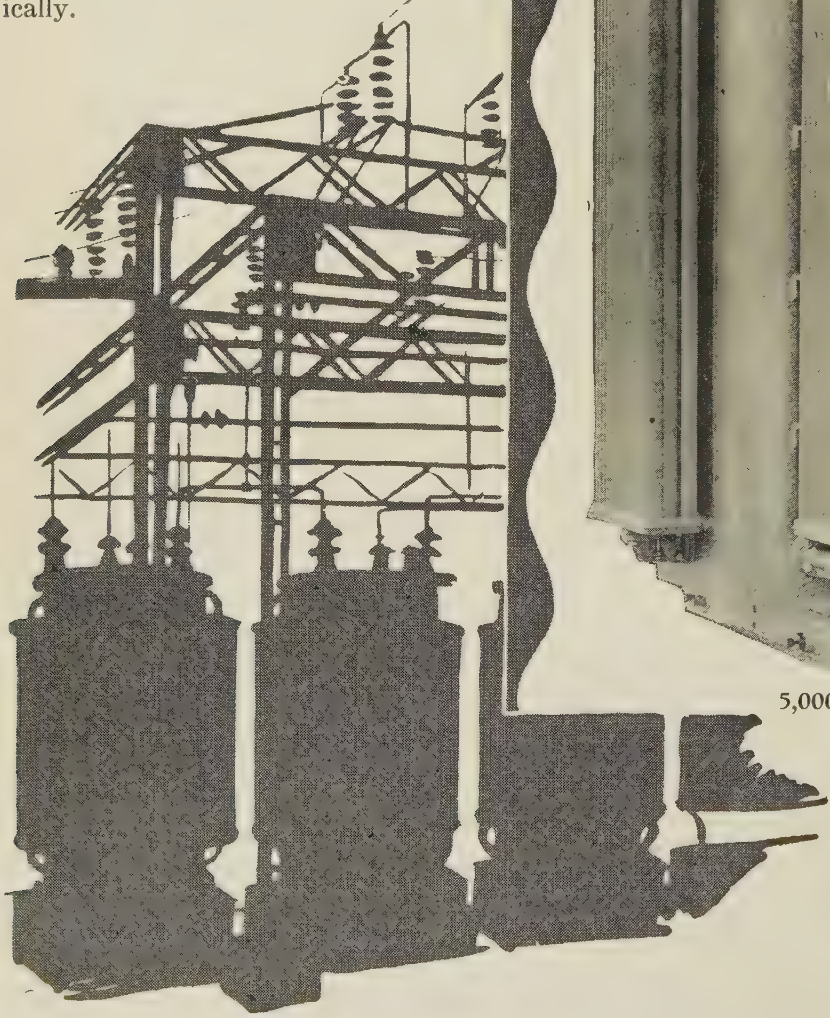
from mine to consumer

MOLONEY TRANSFORMERS

Moloney Transformers are giving satisfactory service to users all over the United States because of—High insulating qualities—Low losses apportioned to give the greatest all day efficiency—Liberal design and large cooling surfaces, insuring effective heat dissipation and ample load carrying capacity. Moloney Transformers continue to serve the interests of Light and Power companies most economically.



5,000 k.v.a., 75,000 volts



MOLONEY ELECTRIC COMPANY, *Main Office and Factories:* ST. LOUIS, MO.

Sales Offices in Principal Cities

A WORD TO A. I. E. E. MEMBERS

The manufacturer of an ordinary product such as a dining room table or a package of gum can *sell* an article to a consumer and *forget* all about it.

SELLING AND THEN FORGETTING

But the successful manufacturer of electrical equipment for today, tomorrow and the years to come *cannot* simply *sell* his product—and *forget* about it.

DELTA-STAR, in building to its position of leadership, has *deliberately* developed an inter-relationship with its customers never before known in the high voltage equipment field of the electrical industry.

In this industry where a highly specialized *engineering* service is involved, buyers have by experience learned that DELTA-STAR *realizes* today's requirements demand more than just *selling* —and then *forgetting.*

Service, helpfulness, continued interest and a sense of *responsibility* in its product—is a *dominating* policy which has helped put UNIT TYPE equipment where it is today.

Do You Read Advertising?

¶SINCE 1912 WE HAVE CONSISTENTLY ADVERTISED DELTA-STAR PRODUCTS with a strong conviction they would hold their place in your favor *despite* competition. The actual proof of that—is the steady growth this company has enjoyed and its outstanding *leadership* today.

¶As a buyer and user you will quickly see that if the product had *not* stood the test of comparison our large manufacturing plants could *not* have been built.

¶You know, and *every* man with experience knows, that a manufacturer who can *consistently* advertise his products year after year is very *sure* of his quality—that is one reason you may be *sure* of it too.

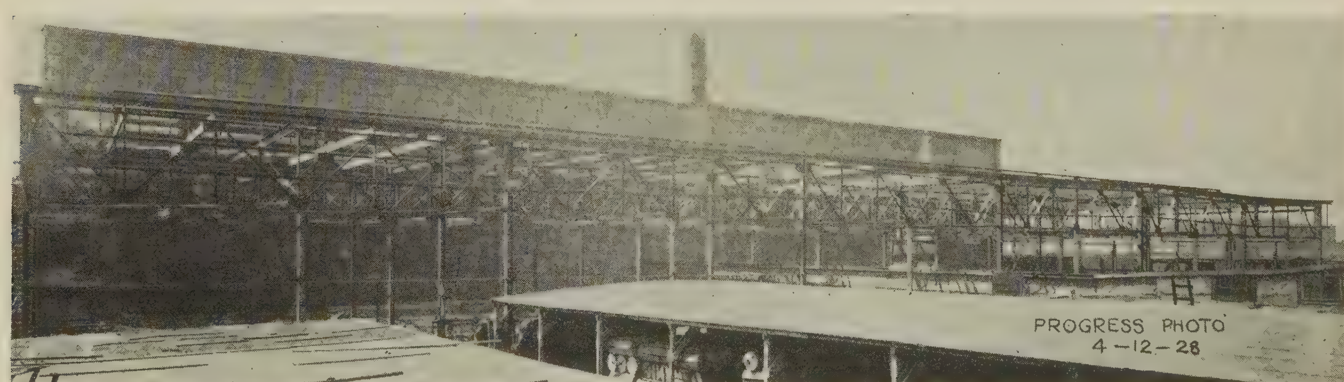
50000 LB. TESTING MACHINES IN OUR 750000 VOLT LABORATORY

Famous Guessers in History!

¶Are you reading the historical advertisements on page 12 of our monthly magazine—if so, does it "click"? The pages of history are replete with instances where lack of foresight, or erroneous supposition turned the tide of success against those who thus failed to provide for the unexpected.

¶. . . Hamilcar Barca of the Carthaginians, Harold of Saxony, King John the Good, Philip of Spain, Napoleon at Waterloo and the British at Trenton, in turn, paid dearly for their fallacious assumptions each justly earning the sobriquet of a "famous guesser".

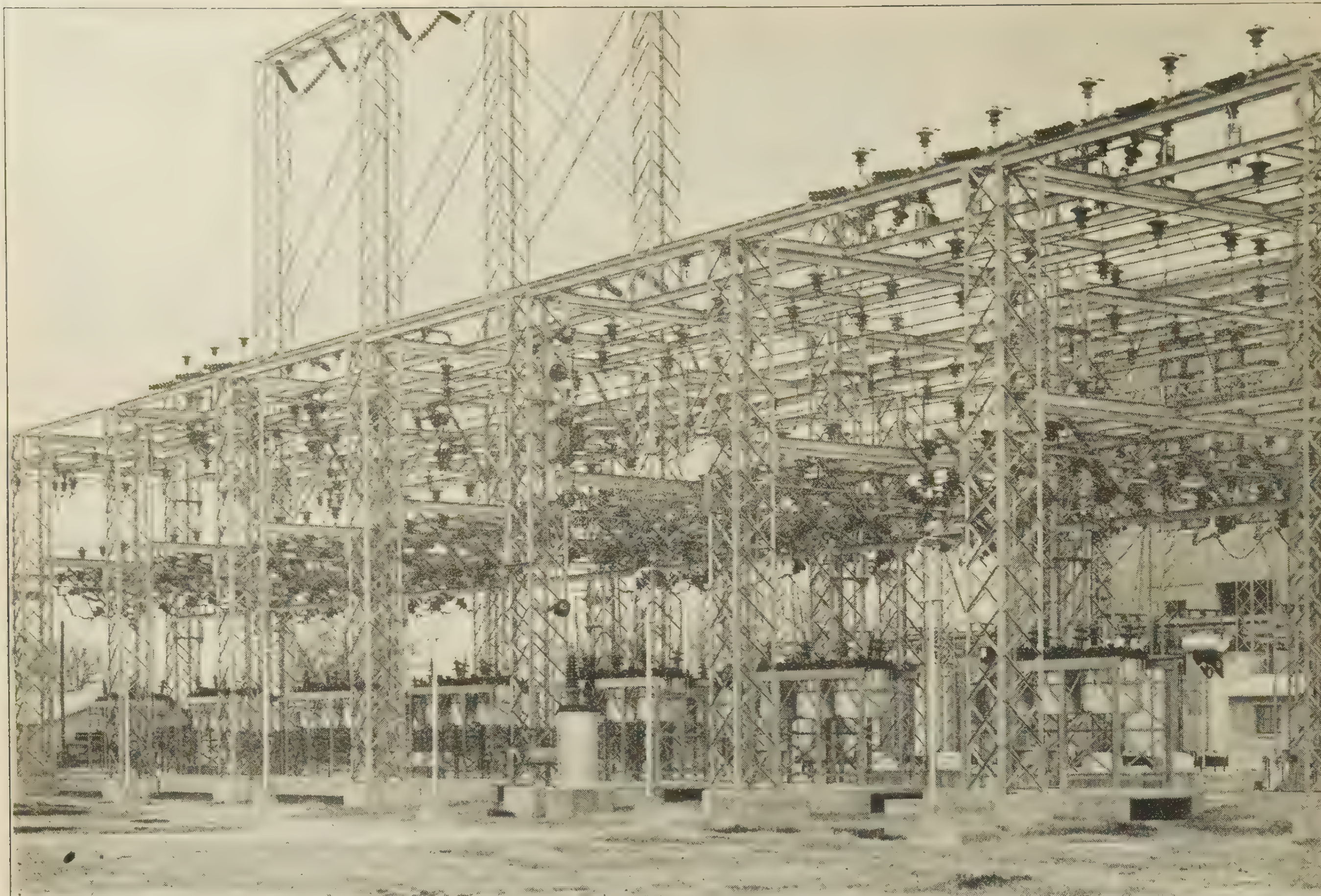
¶Later on we will, in the DELTA-STAR magazine, tell you about some famous "go getters" in history. Your name and address will insure your receiving this magazine every month.



ONE OF OUR NEW SWITCH ASSEMBLY BUILDINGS UNDER CONSTRUCTION AND GOING INTO PRODUCTION JUNE 4TH

DELTA-STAR

DELTA STAR ELECTRIC CO., 2400 BLOCK, FULTON ST., CHICAGO



PACIFIC ELECTRIC ENGINEERING SERVICE

By ordering Pacific Electric High Voltage Switching Equipment your engineering staff is augmented by our engineering service which has pioneered in the design of high-voltage switching equipment for over twenty years.

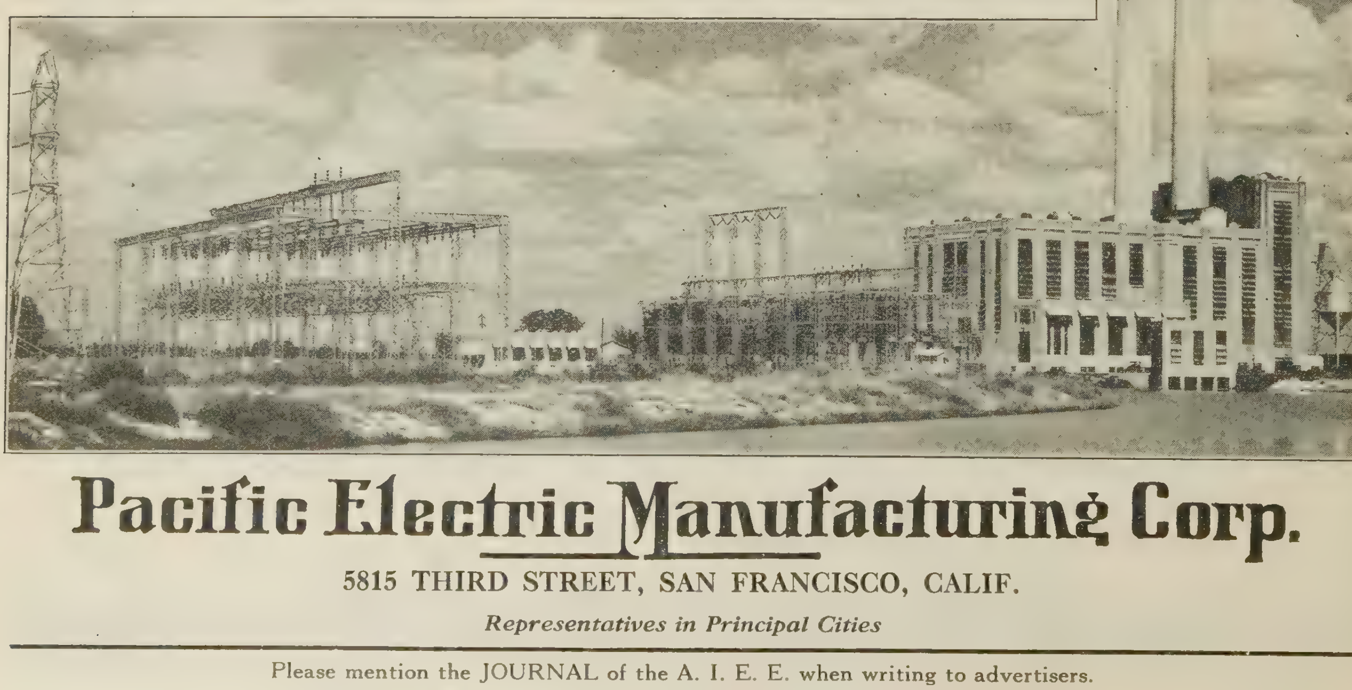
PACIFIC ELECTRIC DESIGNED AND MANUFACTURED EQUIPMENT INSTALLED AT THIS STEAM ELECTRIC STATION

132 KV. LINES

Oil Circuit Breakers, Current Transformers, By-Pass and Disconnecting Switches, Motor Controls and Grounding Switches.

73 KV. LINES

Oil Circuit Breakers, Current Transformers, By-Pass, Disconnecting, Bus Synchronizing and Grounding Switches, Choke Coils and Motor Controls.



Pacific Electric Manufacturing Corp.

5815 THIRD STREET, SAN FRANCISCO, CALIF.

Representatives in Principal Cities

ORGANIZATION

FOR ANY PROJECT

IF you are planning a new development in any field of enterprise we are prepared to help you ORGANIZE it.

We can provide engineers to make investigations, reports or appraisals preliminary to financing.

We can provide financial plans and assist in financing.

We can provide complete designs and the construction personnel to carry out work of any type or magnitude.

PIONEERS SINCE 1889

Stone & Webster, Inc., is the oldest firm in the power industry. Its organization for design and construction is large, widely experienced and extremely flexible. It can design, purchase for and build developments of any size or kind. It has made many records for speed. The power stations built serve 20,000,000 people. In utilities work over $100,000,000 is expended annually.

Industrial work for such companies as Ford, General Motors, American Sugar, U. S. Rubber, Victor and others is measured high in millions and for many clients has been continuous for years. Experience also includes construction of large buildings for such clients as The Insurance Company of North America, University of Pittsburgh, The First National Bank of Boston and others.

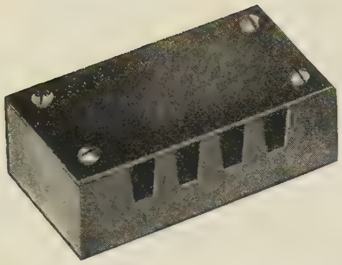
Hundreds of reports have been made covering financial requirements, physical condition, operating costs, inventories, plant extensions, earning power and other features. Properties to the value of $6,000,000,000 have been appraised.

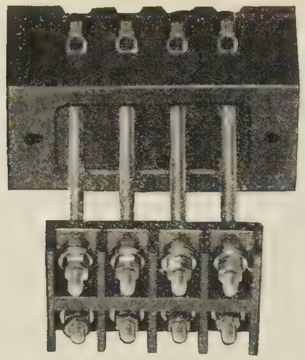
As executive managers, Stone & Webster handle the operation, engineering, purchasing, construction and financial requirements of sixty separate public utility and industrial companies. Recently the Coffin Award, the highest in the gift of the street railway industry, was won by a Stone & Webster company.

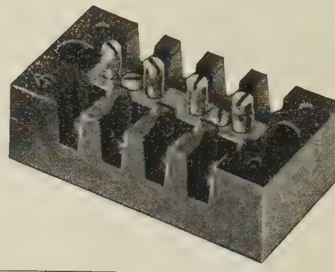
STONE & WEBSTER

INCORPORATED

OPERATE FINANCE BUILD







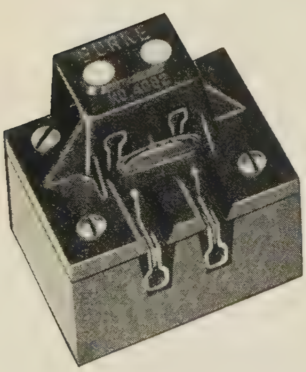
BURKE

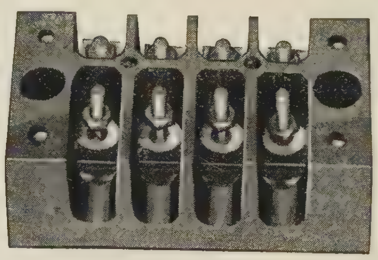
Combination
Controlead Terminal Blocks

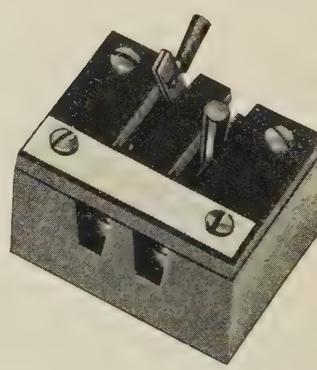
METER and RELAY TEST SWITCHES
Potential and Current Short Circuiting Type
Front or Back of Board Mounting

Bulletin Furnished on Request

BURKE ELECTRIC COMPANY
ERIE, PENNSYLVANIA
Sales Offices in Principal Cities







The Oil-Tight Joint Is Here

A Porcelain Ring *Soldered* Directly into the Lead Sleeve

An oil-tight joint with insulating ring to limit sheath losses embodying these advantages:

No Gaskets
No Moulded Parts
Porcelain Sectionalizing Ring
Unaffected by Temperature Changes
Glazed Creepage Surface
    Easily Kept Clean
    Unaffected by Manhole Conditions
    Retains Efficiency for Life of Installation
Absolutely and Permanently Oil-Tight

The high voltage joint shown below is the most recent development in the line of STANDARD Accessories.

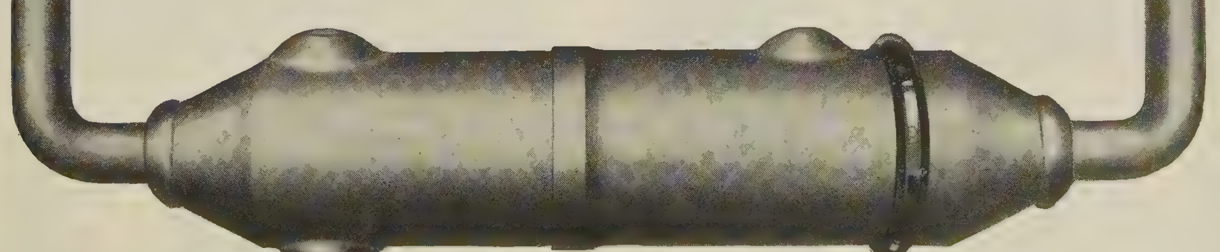
This process of *soldering* metal to porcelain is also used to advantage in many types of oil filled terminals.

STANDARD UNDERGROUND CABLE CO.

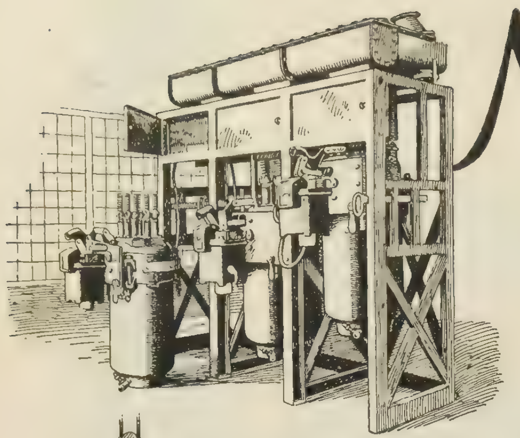
Division of General Cable Corporation
General Offices: Pittsburgh, Pa.

Boston	Washington	Chicago	Kansas City
New York	Atlanta	Detroit	Seattle
Philadelphia	Pittsburgh	St. Louis	Los Angeles
	San Francisco		

Manufacturers of bare and insulated
Electric Wires and Cables for all purposes,
also Cable Accessories.

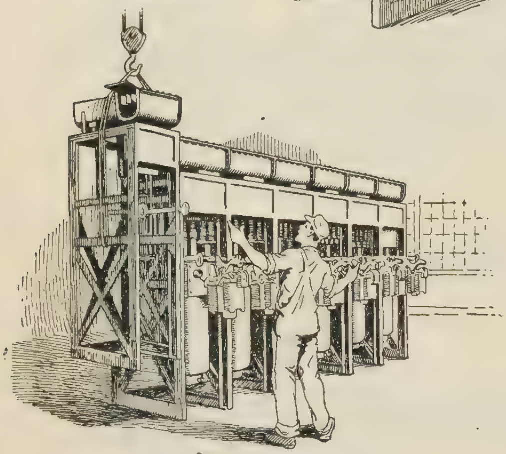


Metal-Clad



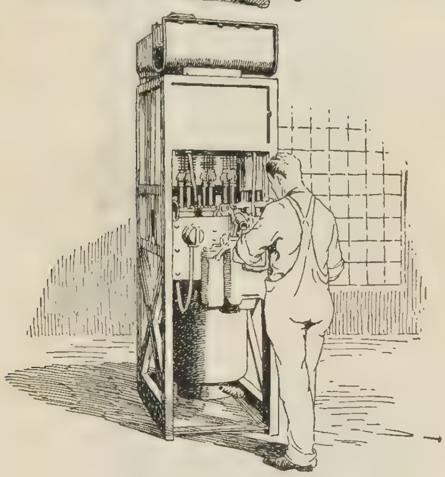
Safety for Operators

All live parts are completely enclosed while the equipment is in operation. Repairs can be made in safety while the breaker is disconnected.



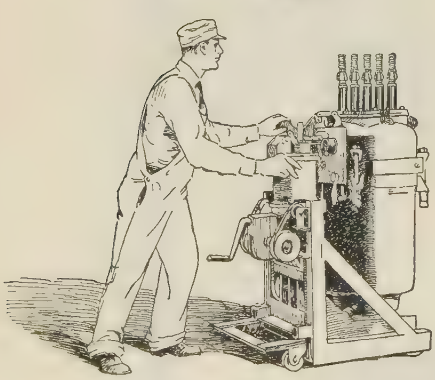
Simple to Install

Each unit includes an oil circuit breaker, buses, instrument transformers, disconnecting devices, and frame work completely assembled and wired ready to install.



Compact Construction

These units are so constructed as to require small floor space and still provide liberal clearances and ready accessibility.



Economy of Maintenance

A spare circuit breaker can be substituted quickly and easily when inspection or adjustment is necessary—and with but short interruption of service.

GENERAL

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Switchgear

Safety for operators, simplicity of installation, compact construction and economical maintenance are among the advantages which characterize metal-clad switchgear.

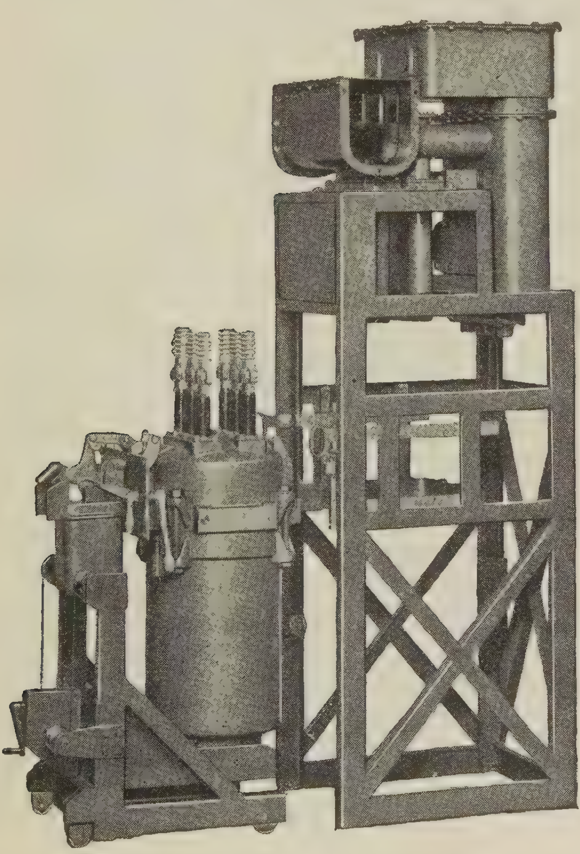
The design utilizes standard oil circuit breakers, supported in a frame of welded structural steel. This frame carries a cradle on which the breaker unit can be raised and lowered by means of an installing truck. The frame also carries the bus and instrument transformer compartments and the disconnecting devices.

To put the equipment in operation, the breaker unit on the installing truck is slid into the frame and raised until full contact is made. To withdraw the unit, this operation is reversed. Interlocks are provided to prevent insertion or withdrawal when a breaker is closed.

The main buses are covered with a molded insulation and enclosed in a metal bus compartment which may be filled with insulating fluid.

As each part is segregated in a metal compartment, fire risks from internal or external sources are minimized.

G-E switchgear specialists will explain to you the advantages of this equipment. Ask our nearest sales office for publication GEA-966.



View on Assembly Floor Showing Units under Construction

460-26

ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES

The electric power loop

Rotterdam substation. The transformer station from which the loop is fed appears in the background.

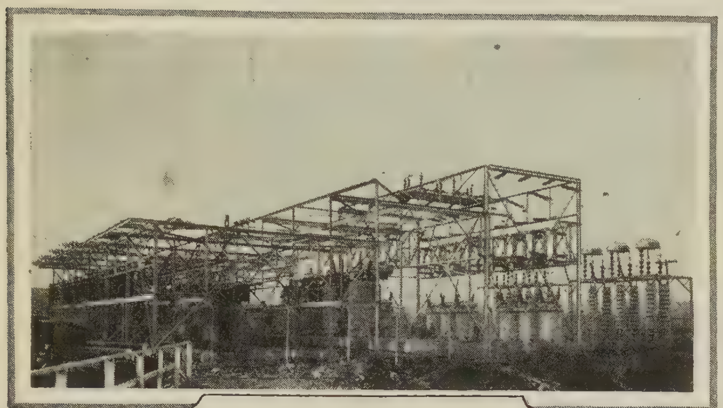
The Woodlawn substation serves part of the residential section. A-C. Reclosing Feeder equipments are shown above.

GE

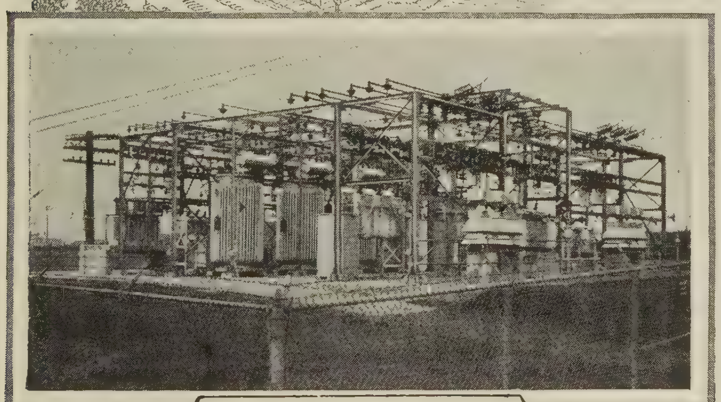
GENERAL

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

a builder of good will



This substation serves the plant of the American Locomotive Company.



The Rosa Road substation is located on the outskirts of the city.

The automatically operated loop system is a builder of good will because it prevents interruptions over a large area.

At Schenectady, N. Y., such a system serves a community of more than 100,000 people. Power is fed in both directions through the loop at 13,200 volts. If, at any substation, trouble occurs which interrupts the power flow in one direction through the loop, this station is fed from the opposite direction. Service to consumers is not interrupted.

Automatic a-c. reclosing feeder equipments at each station open the feeders only in case of a severe overload or short circuit. These equipments automatically reclose and open three times if the trouble persists, before the feeder is locked open.

Automatically operated loops, similar to this but serving larger areas and for different conditions, are now operating in different parts of the country.

460-21

ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES

Westinghouse Feeder - Voltage Regulators STAND UP

High torque operating motor for quick voltage correction.

Self-cleaning top bearing—won't stick.

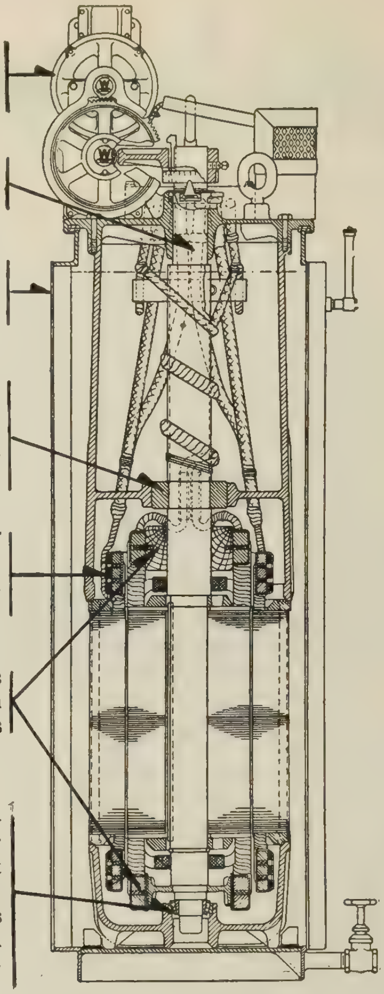
Corrugated all-welded steel tank provides resilience in case of internal explosion.

Upper main rotor bearing. Its position reduces distance between main bearings, resulting in greater rigidity and less vibration.

Insulated steel rings for bracing end of stator coils prevent coil distortion under short-circuit stresses.

Blocks for bracing the ends of the rotor coils result in greater rigidity and less vibration.

Timken tapered roller bearings carry weight of rotor and assure permanent alignment and freedom from vibration. This means sturdiness and prompt functioning of regulators.



Sensitive But Sturdy

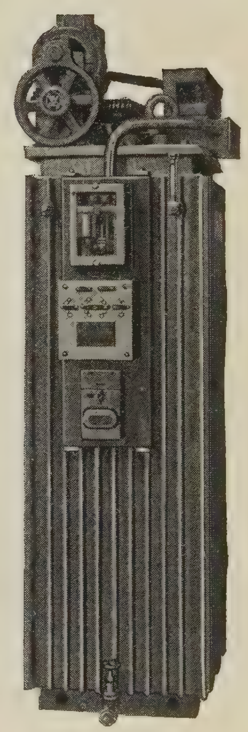
THE efficient performance of feeder-voltage regulators depends upon two important characteristics:

Sensitiveness—quick response to voltage variations.

Sturdiness—ample strength to withstand heavy current surges.

Modern design, including roller bearings at important points—careful selection of raw material for core and coils—expert workmanship and testing of each unit impart to Westinghouse regulators the sensitiveness and sturdiness that account for the many years of service of these regulators in the central station industry.

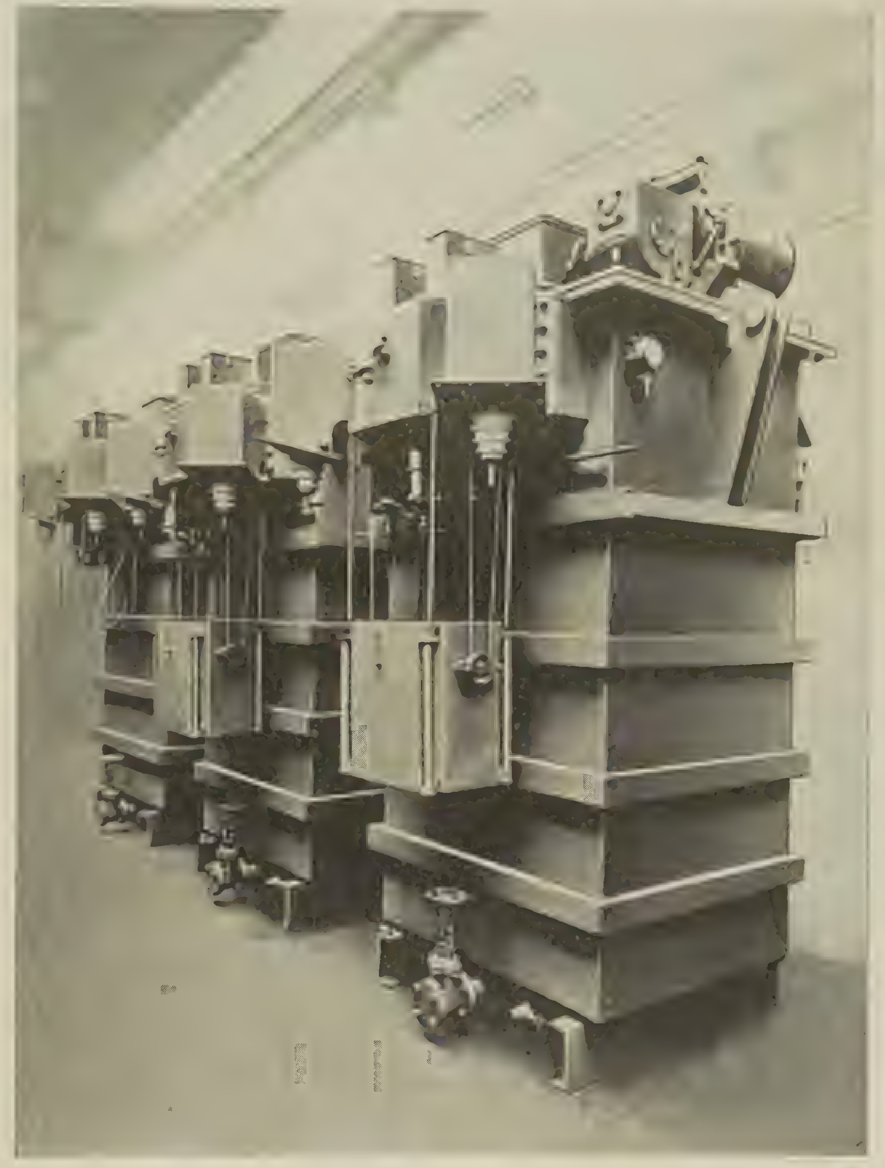
Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries



Westinghouse

X98151

FERRANTI TRANSFORMERS



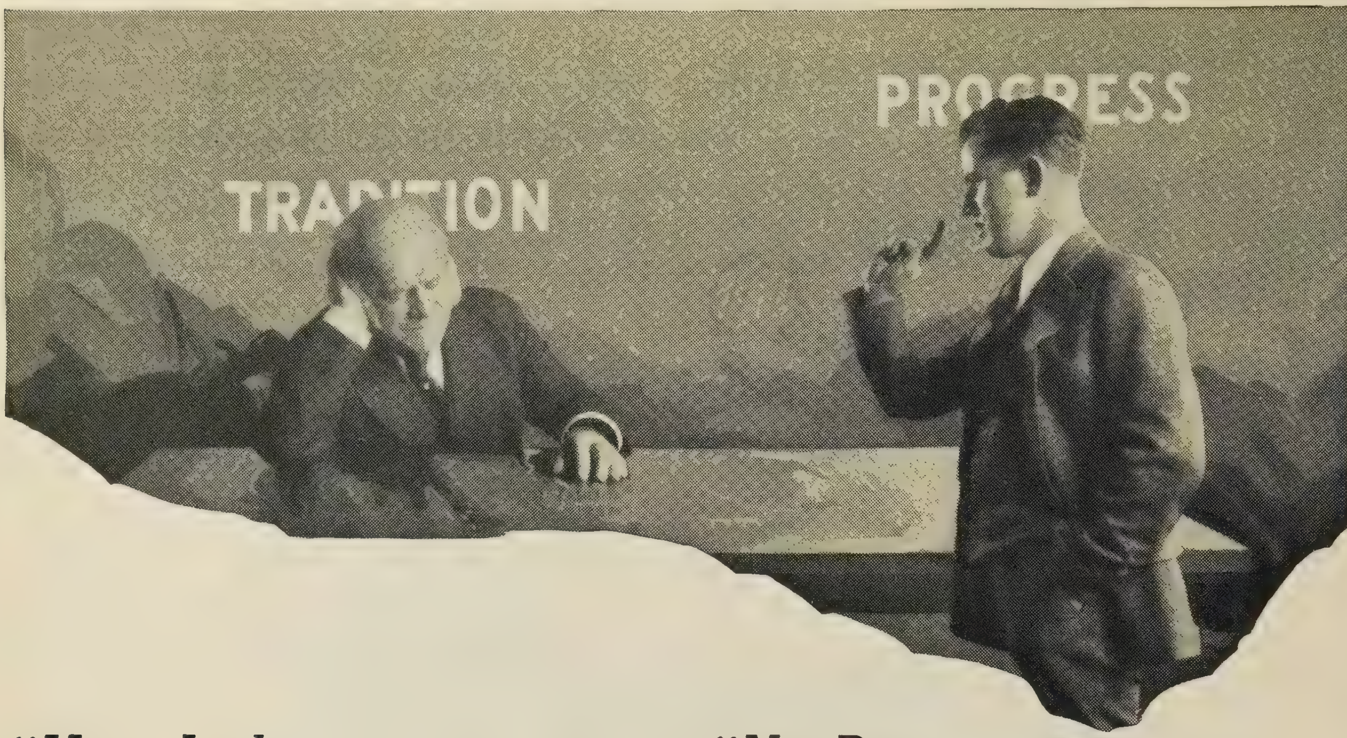
12,000 K. V. A., 33 K. V., 3 PHASE
FERRANTI TRANSFORMER GROUP WITH
EQUIPMENT FOR CHANGING TAPS UNDER LOAD

FERRANTI, INC.
130 W. 42nd STREET
NEW YORK

FERRANTI, LTD.
HOLLINWOOD
ENGLAND

FERRANTI ELECTRIC
LIMITED
TORONTO, CANADA

Economy of manufacture depends on modern methods



"Here, Lad—

I'm getting along in years and have my shop so well organized and my ideals on good construction so firmly set that for me to give up cast construction on our machines and go to arc welding—well, I'm just too old to learn."

"No, Pop—

age is not a time of life—it's a state of mind—and that can be changed without deserting your ideal.

Your ideal is solid, dependable construction.

You'll get a more solid and a more dependable construction with a 'Stable-Arc' welded base and frame.

That *lifts* your ideal.

Another of your ideals is to build a solid, substantial company.

'Stable-Arc' welded construction on our machines will save us at least $30 per machine.

That will hasten your ideal in these days when industrial battles are fought on the shop floor rather than the sales floor.

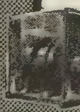
And you're not too old to learn, Pop—although you may be too young to realize it."

A new textbook on Arc Welding, (Price $1.50) will be sent on approval for five days to any executive requesting it.

Book size, 6" x 9"—total pages, 160—number of illustrations, 200—Charts, 62—Divisions, 8.

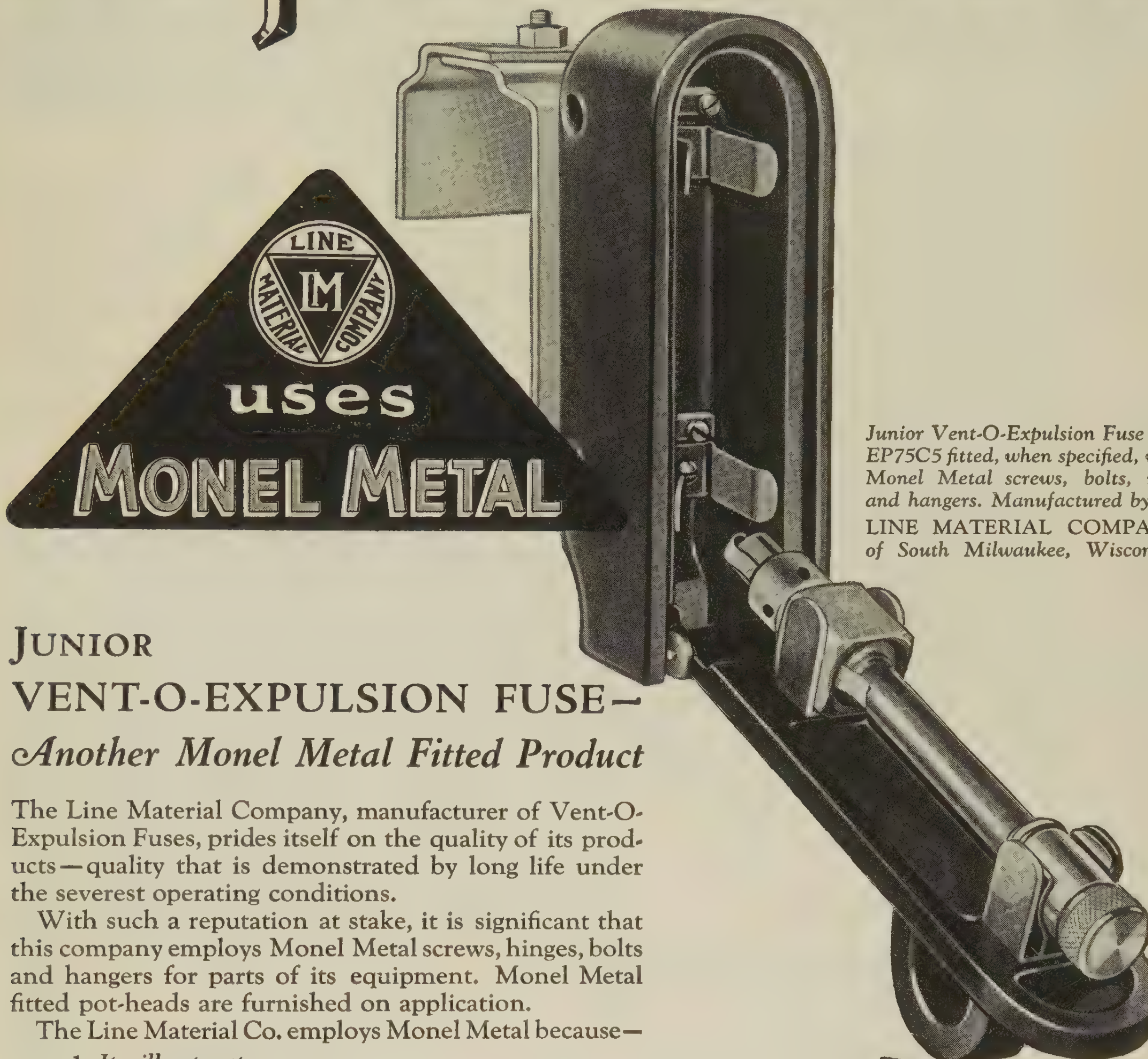
The Lincoln Electric Co., Dept. No. 21-6, Cleveland, Ohio

W-49



"Stable-Arc" LINCOLN WELDER

dependable



Junior Vent-O-Expulsion Fuse No. EP75C5 fitted, when specified, with Monel Metal screws, bolts, nuts and hangers. Manufactured by the LINE MATERIAL COMPANY *of South Milwaukee, Wisconsin.*

JUNIOR VENT-O-EXPULSION FUSE–

Another Monel Metal Fitted Product

The Line Material Company, manufacturer of Vent-O-Expulsion Fuses, prides itself on the quality of its products—quality that is demonstrated by long life under the severest operating conditions.

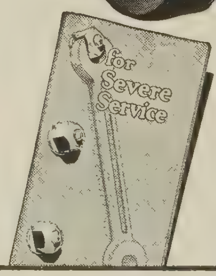
With such a reputation at stake, it is significant that this company employs Monel Metal screws, hinges, bolts and hangers for parts of its equipment. Monel Metal fitted pot-heads are furnished on application.

The Line Material Co. employs Monel Metal because—

1. *It will not rust—*
2. *It is not subject to corrosion-cracking—*
3. *It has uniform strength to withstand the strains incident to severe line service—*
4. *Its rolled structure insures unfailing dependability—*
5. *It is available in all the shapes and forms required for the ready fabrication of this type of equipment.*

MONEL METAL will be exhibited at the N.E.L.A. Exposition, Atlantic City, N. J., June 4—8, 1928.

You know from past experience that leading manufacturers use only time-tried materials. Therefore, since the leaders use Monel Metal, you may also know that you can insure dependability by specifying Monel Metal.



This little booklet—"For Severe Service"—will give you interesting and helpful information about Monel Metal. Send for your copy today!

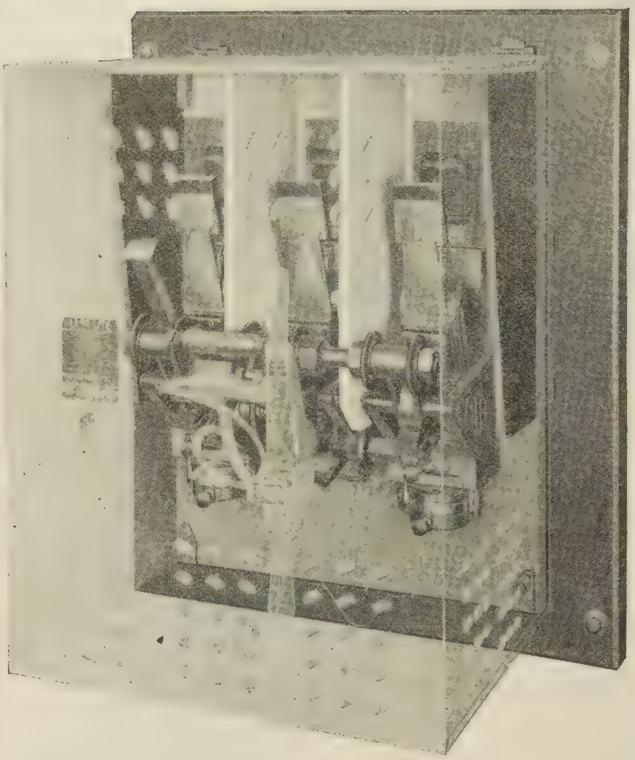
Monel Metal is a technically controlled Nickel-Copper alloy of high nickel content. It is mined, smelted, refined, rolled and marketed solely by The International Nickel Company. The name "Monel Metal" is a registered trade mark.

MONEL METAL

INCO MONEL METAL TRADE MARK

THE INTERNATIONAL NICKEL COMPANY (INC.) 67 WALL STREET, NEW YORK, N. Y.

FOR A·C· CIRCUITS
550 VOLTS AND LESS



AUTO U-RE-LITE—TYPE LL—550 VOLTS, 1000 AMPS.

U-RE-LITE has distinct advantages

not present in any other type of electrical protective apparatus

1. No oil to leak, carbonize, burn or explode.
2. Immersed in air—a self-restoring medium.
3. Inherent simplicity—resulting in low cost installation and maintenance.
4. Practically unlimited rupturing capacity—as proven on test.
5. Steel encased—entire safety to the operator regardless of load conditions or short circuits.
6. Adaptability—for across the line starting and also affording:

INSTANT protection against short circuits while running or when being closed.

TIMELY protection from sustained overload.

EFFECTIVE protection against single phasing.

If you are not using U-RE-LITE, study from all angles your present method of protecting A. C. Motors and Feeders.

Is there any other equipment on the market which can be described as having all of these features?

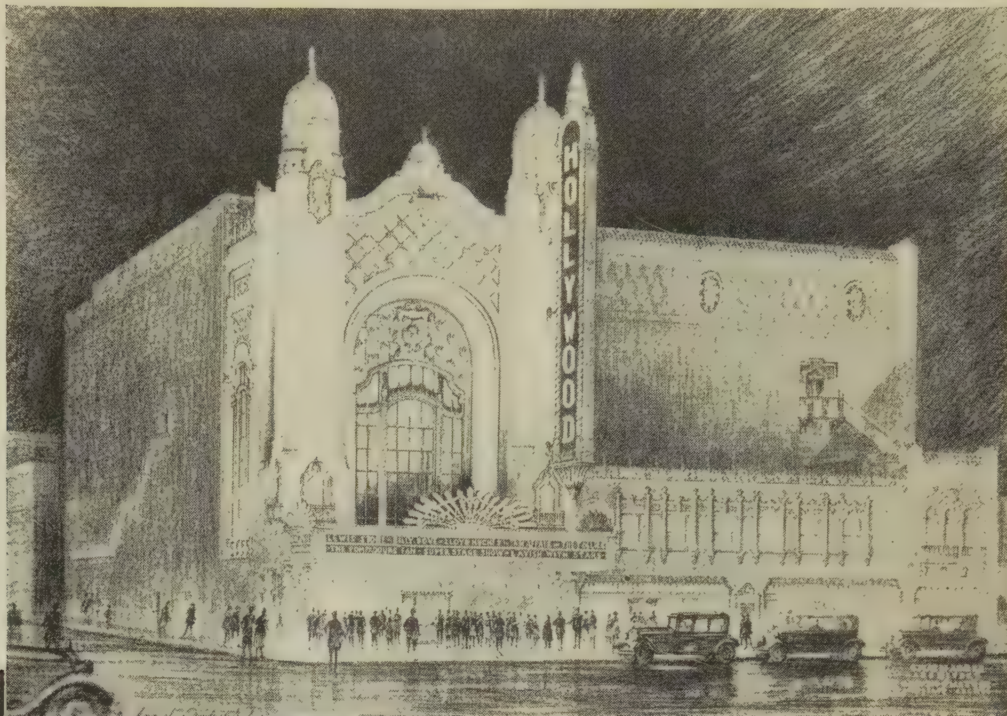
I-T-E CIRCUIT BREAKER COMPANY—505 N. 19th STREET, PHILADELPHIA

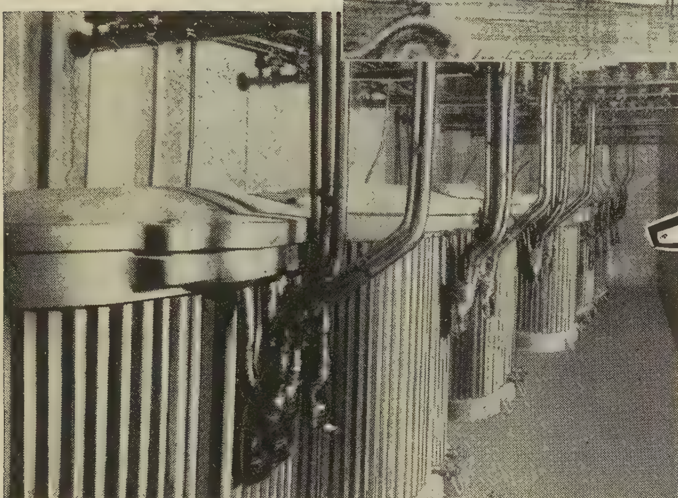
Birmingham, 1401 Lomb Ave., P.O. Box 2310; **Boston**, 201 Devonshire; **Buffalo**, Ellicott Sq. Bldg.; **Chicago**, 53 W. Jackson; **Cincinnati**, Union Trust Bldg.; **Cleveland**, 1740 E. 12th; **Dallas**, 1410 Allen Bldg. **Denver**, Tramway Bldg.; **Detroit**, Penobscot Bldg.; **Kansas City**, Midland Bldg.; **Los Angeles**, 106 W. 3rd; **Minneapolis**, Plymouth Bldg.; **Montreal**, 698 St. Catherine; **New Orleans**, Hibernia Bank Bldg.; **New York**, 12 E. 41st; **Omaha**, Electric Bldg.; **Philadelphia**, 1505 Race; **Pittsburgh**, Park Bldg.; **St. Louis**, Bank of Commerce Bldg.; **San Francisco**, Call Bldg.; **Seattle**, 2518 Western; **Toronto**, 24 Adelaide, E.; **Vancouver**, 615 Pender, W.; **Tulsa, Oklahoma**, Box 1141.

U-RE-LITE
THE I-T-E CIRCUIT BREAKER IN THE STEEL BOX

SEE KUHLMAN TRANSFORMERS IN BOOTH 383 AT THE N.E.L.A. EXHIBITION

In Detroit's Newest and Finest Theatre





Another!

Kuhlman Installation

The fact being emphasized by this installation series is simply that Kuhlman Transformers are day-after-day doing their work well in Central Stations, Sub-Stations, Industrial plants, Theatres, Railroads, and a host of other special fields.

Each installation is additional testimony to the complete reliability and high operating efficiency of Kuhlman Transformers.

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Cleveland....627 Union Trust Bldg.
Dallas....1408 Allen Bldg.
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Indianapolis..202 Indiana Ter. Whse.
Lincoln, Neb....1425-35 M St.
Los Angeles 316 American Bank Bldg.
Milwaukee....1031 Clybourn St.
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New Orleans....1230 Hibernian Bank Bldg.
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San Francisco....Call Bldg.
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Rectangular Base
Film Type Radiators
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Double Magnetic
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Elliptical Coils

2500 K.V.A.
11000 Volts H.V.
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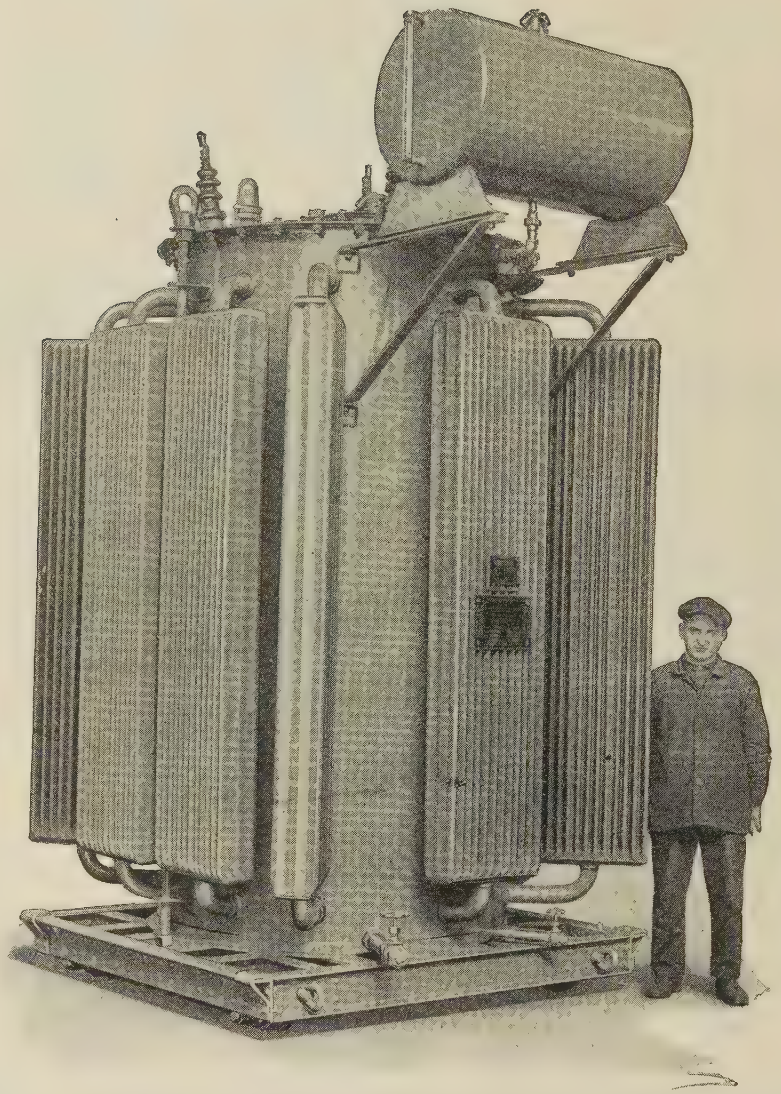
60 Cycles
55° C.



ALLIS-CHALMERS MANUFACTURING CO.
PITTSBURGH TRANSFORMER WORKS
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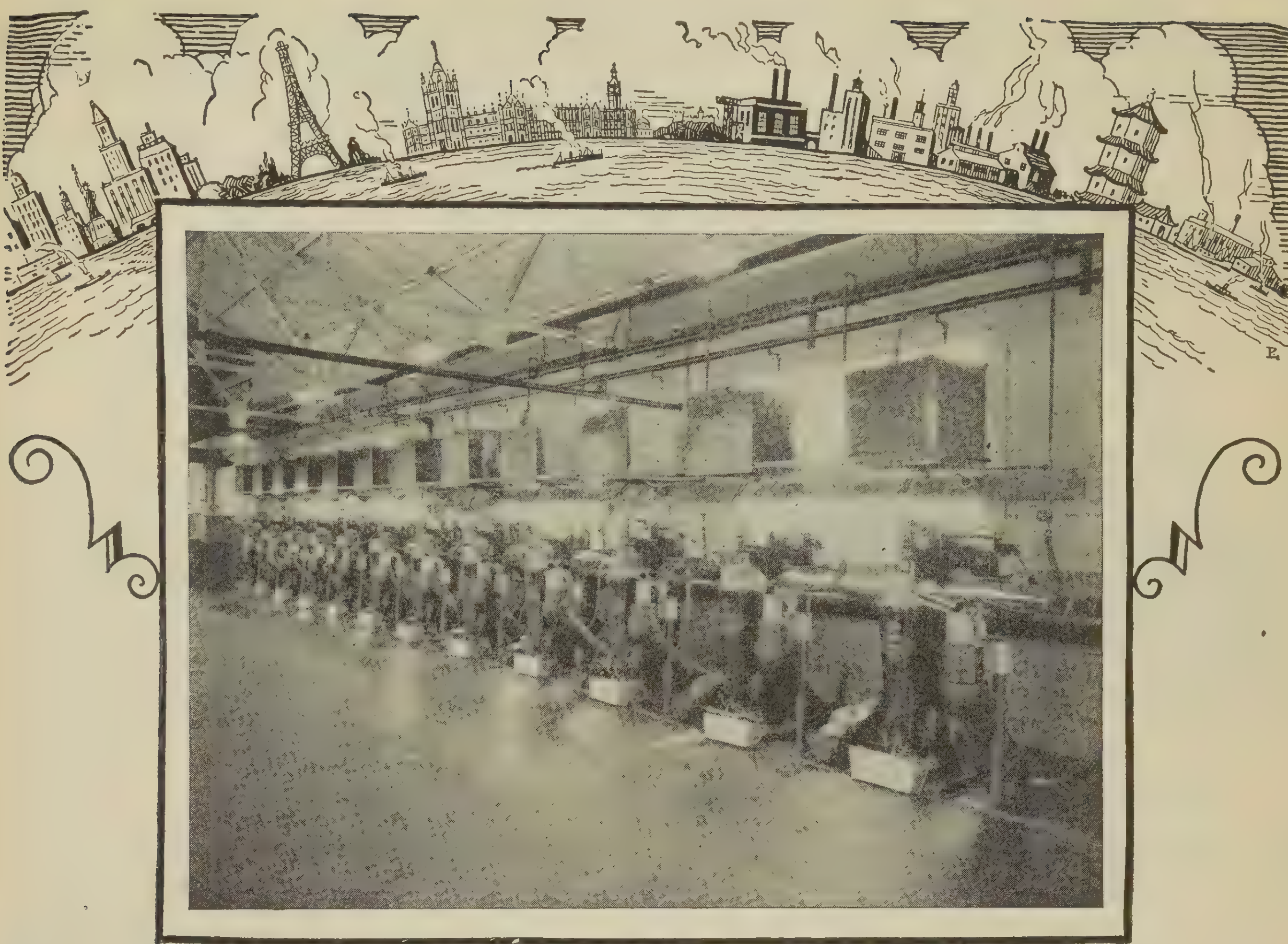

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SPECIALIZATION and concentration in the development of centrifugal processes have given Sharples Engineers a knowledge and practice in clarification, separation and dehydration possessed by no other organization. In the application of Centrifugal Force, Sharples unquestionably stands first. It is only natural, therefore, that the outstanding centrifugal processes and largest installations in the world are Sharples.

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Wired with

ASW 30% Wire

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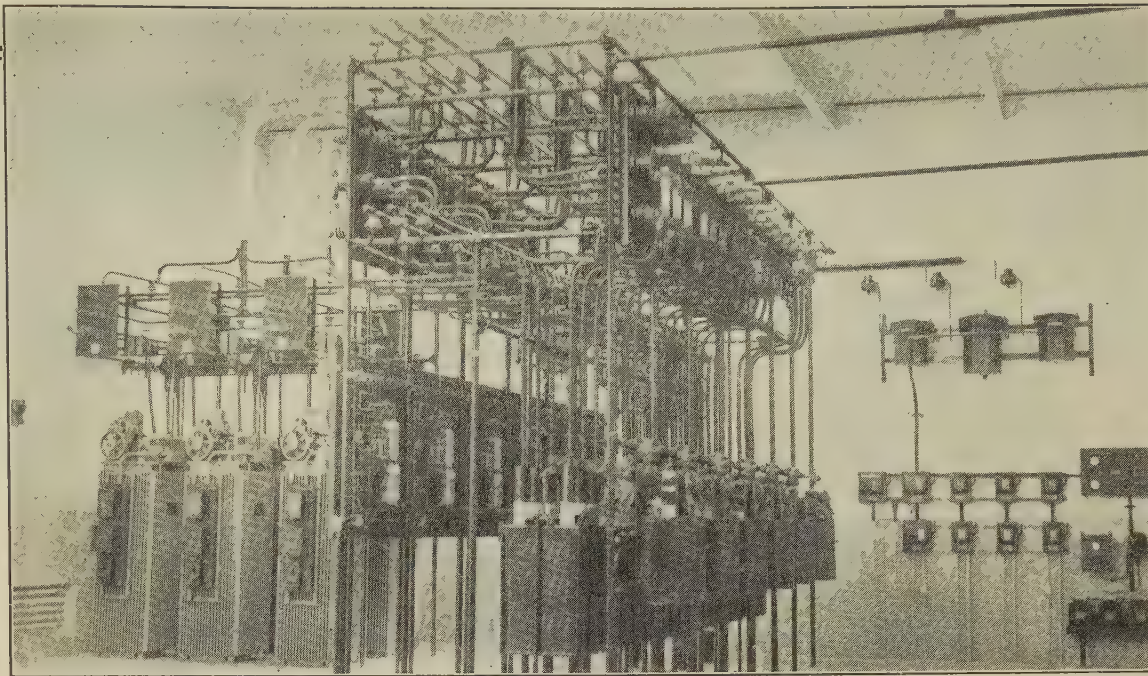

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GENERAL OFFICES AND WAREHOUSE
GARFIELD 6356

SAN FRANCISCO, CALIF

May 4, 1928.

Dossert & Company,
242 West 41st St.,
New York, N.Y.

Gentlemen: Attn. Mr.H.B.Logan, Pres.

We are pleased to enclose herewith copy of a photograph of a very nice little sub-station on the lines of the Coast Counties Gas & Electric Company, at Morgan Hill, California.

This is a very small station, but has approximately one hundred and twenty-five Dossert Cable Taps and Connectors on the Buss Branch Feeders, etc.

I think this shows how economically Buss Branch Feeders can be taken off by the use of Dossert Connectors.

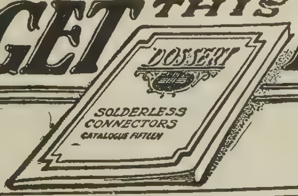
Yours very truly,
H. B. SQUIRES COMPANY.
S. P. Russell
S. P. RUSSELL.
President.

SPR/DM

Many
Dossert Connectors
in this little substation

The letter tells the story

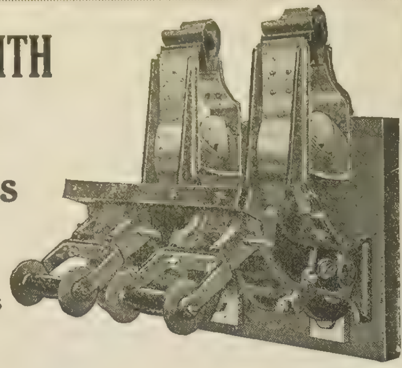
GET THIS BOOK *—it's Free—*



More than 1,000 types, sizes and combinations in the Dossert Year Book

DOSSERT & COMPANY
H. B. Logan, Pres. **242 West 41st St., New York**

ROLLER-SMITH Circuit Breakers



All Types
For All Purposes

3 to 12,000 amperes
600 volts and less
Direct and Alternating Current

One, Two, Three and Four Pole Overload, underload, over-voltage, under-voltage, shunt trip, reverse current and combinations. Free handle; time limit; remote control; interlocked; open and enclosed.

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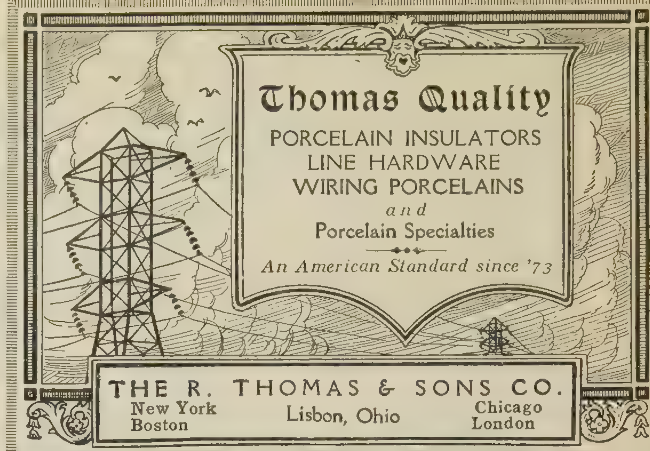
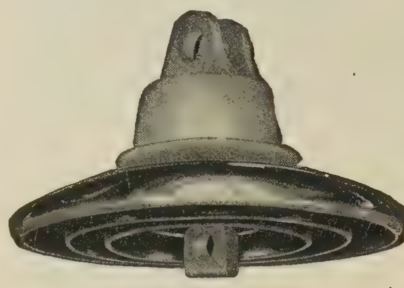


INSULATORS



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Automatic Starters
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Float Switches
Hand Starters
Magnet Switches

Pressure Regulators
Remote Switches
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The transparency of Hemingray Glass Insulators makes line inspection very simple. The lineman can tell at a glance whether the insulator is intact or not. Hemingray insulators are mechanically and dielectrically dependable, non-porous and uniform in structure. They defy moisture and age.

Send for Bulletin No. 1.

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Muncie, Indiana

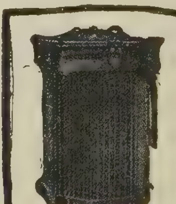
Practically all our original customers are still on the books

We have been rewinding burnt-out transformers and selling good rebuilt units to prominent central stations for the past decade. What is more, our oldest customers are still with us.

Write for our Monthly Bulletin of offerings in rebuilt transformers from 1 to 1000 K.V.A., 110 to 66,000 volts. Our stock averages 4,000 units for immediate shipment. Rewinding prices are very reasonable for first-class work.

WE BUY MODERN TYPE TRANSFORMERS—ANY SIZE—ANY QUANTITY.

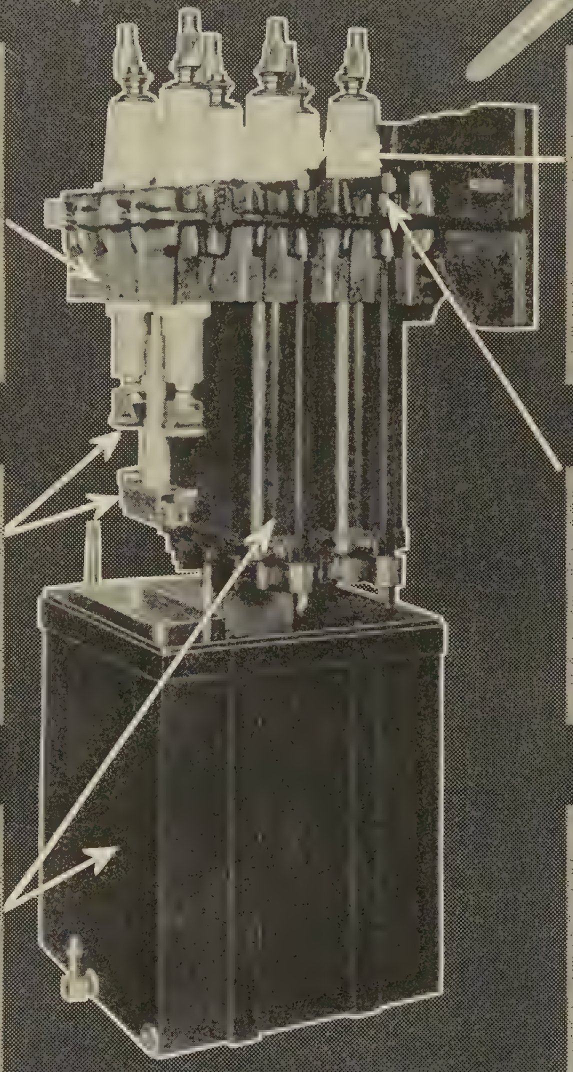
The ELECTRIC SERVICE CO. Inc.
America's Used Transformer Clearing House
212 Walnut Street Cincinnati, Ohio



New

Improved Frame—Heavily ribbed with deep extending web surrounding the tanks and tank land affords unequaled strength and rigidity to resist shocks and impacts.

Oversize Bushings—Of greater mechanical strength to withstand high inrush currents. One-piece, wet-process, porcelain extending below the oil line and securely clamped to the frame, provide insulation in excess of A.I.E.E. requirements.



New Contacts—Inverted laminated brushes of special design withstand extremely high inrush currents. Exceptionally heavy arcing contacts with large thermal absorption capacity materially reduce arcing on interruption.

Improved Energy Absorption Feature—Stronger resilient tank supports mean added ability to absorb the shock of rupturing heavy short circuits.

Sturdier Tanks—Individual inner tank per pole of thick steel plate scientifically welded is supported by a heavily ribbed cradle resiliently hung. Large outer tank is supported by strong steel rods. Expanding gases and oil vapor is condensed. Condensed oil vapor is confined by outer tank.

Stronger Mechanism—But light in weight and more powerful accelerating springs assisted by the strong spring action of the new contacts assure high speed of interruption.

Type D-131

CONDIT ELECTRICAL MFG. CORPORATION
Manufacturers of Electrical Protective Devices
BOSTON, MASS.
Northern Electric Company
Distributor for the Dominion of Canada

SPECIFICATIONS: — *600, 800, 1200 Amperes, 15,000 Volts; 1600 Amperes, 7500 Volts. Estimated interrupting capacity 7000 Amperes at 15,000 Volts.*

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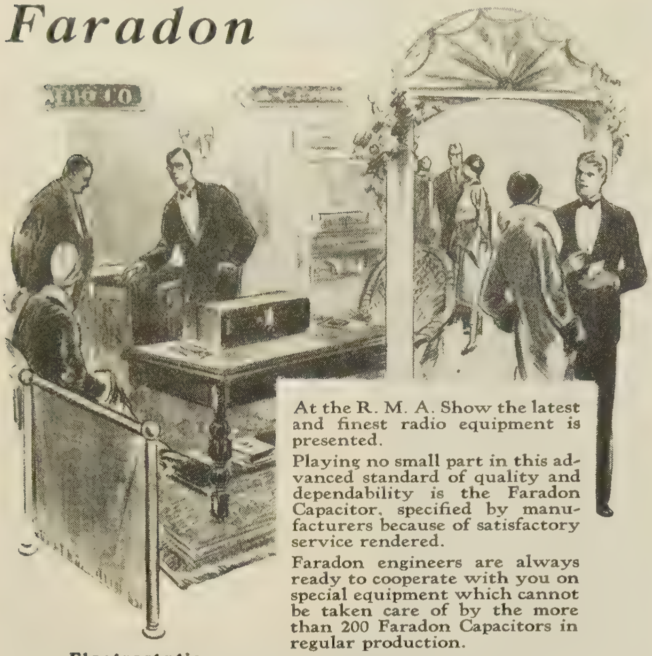

At the R. M. A. Show the latest and finest radio equipment is presented.

Playing no small part in this advanced standard of quality and dependability is the Faradon Capacitor, specified by manufacturers because of satisfactory service rendered.

Faradon engineers are always ready to cooperate with you on special equipment which cannot be taken care of by the more than 200 Faradon Capacitors in regular production.

Electrostatic Condensers for all purposes

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Jamaica Plain,
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Beat Frequency Oscillator

RANGE 15 - 9,000 CYCLES

TYPE 413 OSCILLATOR

It is of great advantage in making audio frequency measurements to have the frequency quickly variable by means of a single control.

In the type 413 oscillator the single control feature is made possible by use of the beat frequency between two high frequency oscillators.

The type 413 oscillator is particularly adaptable to loud speaker measurements.

Licensed under Pat. No. 1113149 for laboratory experimental uses only where no commercial features are involved.

Type 413 Oscillator....... Price $210.00

Described in Bulletin 6150-E.

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A Visual Oscillograph

Simple to Operate—An instrument no more difficult to operate than a high grade radio receiving set.

Portable—Weighing but 40 pounds in its beautiful walnut cabinet, it is easily taken from research room to lecture room or to a distant substation.

Linear Time Axis—By the use of a unique scheme, a linear time axis is obtained which is synchronized with the circuit under study, so that a perfectly stationary visual wave is obtained which may be examined with great care, traced or photographed.

High Frequencies—As there is no damping and the inertia of the electron beam is only 10^{-18} grams, the response to all frequencies and harmonics is true and accurate.

Small Current—One micro-ampere is sufficient to actuate this small moving element.

Immediate Results—Because it is visual, a class in Electrical Engineering or Radio can watch the effect of changing the constants in any circuit *while it is happening.* A power engineer can observe the effect on wave form of various loads, field excitations, etc., making a photographic record of the results which it is deemed should be permanent.

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Paper condensers, long considered satisfactory in Radio, are no longer competent to give the service required in the new Electrical Sets.

Mershon Condensers are particularly well suited to power supply devices employing the 210 tube. They COST LESS than a paper condenser block designed for 210 operation and are MUCH MORE EFFICIENT.

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The use of Jewell "Master" instruments promises so many advantages over the use of other portables that they should be investigated and be made a part of every electrical testing equipment.

"Master" portables are available as A. C. and D. C. voltmeters and ammeters, single and double scales, as single and double range wattmeters, and as a combined volt-amp-wattmeter. This wide variety of available types provides a real advantage in the selection of the instrument best suited to your need.

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In the Pattern No. 172 a large, highly perfected movement with outstanding features of insulation and ruggedness provides built-in advantages of precision with sustained accuracy.

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√ an excellent insulator

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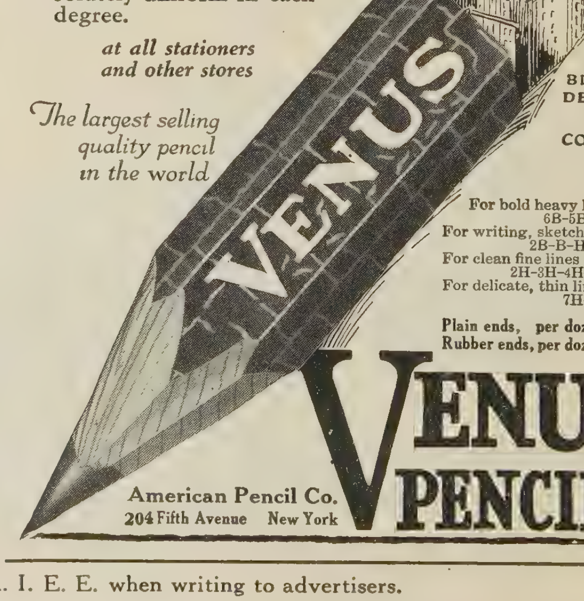

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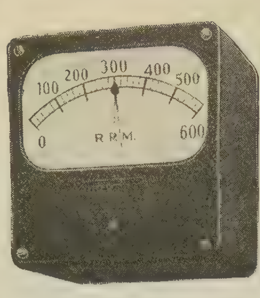

Accurate Speed Indications An Important Aid to Power Plant Efficiency

IN the modern power plant, where many types of revolving machinery are employed, the regulation of speed is of such extreme importance with respect to operating efficiency that the selection of proper speed indicators warrants the serious attention of managing officials and engineers.

In both the Central Station and the isolated power plant there are innumerable uses for a speed indicator whose readings can be observed at any desired points of control remote from the machines whose speeds are being measured. The speeds of main generators, circulating pumps, boiler feed pumps, pulverized coal blowers, screw conveyors and stoker engines are all factors of increasing importance in modern power plant management.

For this service Weston offers an Electric Speed Indicator, consisting of an improved type of magneto having a watertight rugged housing, proof against dirt, moisture, extreme temperature, vibration and shock, and the influence of external magnetic fields. A suitable driving mechanism for the magneto is furnished together with one or more indicators as required, which are calibrated in R.P.M., Gals. per minute, Feet per minute or other desired units.

The Weston Electric Speed Indicator is inherently more accurate than mechanical or hydraulic types. Any wear on mechanical parts does not affect the electrical accuracy of the instrument. Any number of indicators, and a recorder if desired, may be installed at any distance from the device whose speed is being measured. Accuracy of indications is independent of the size or length of connecting cable.

We invite engineering communications.
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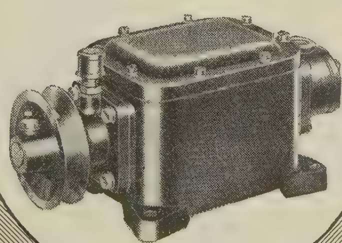

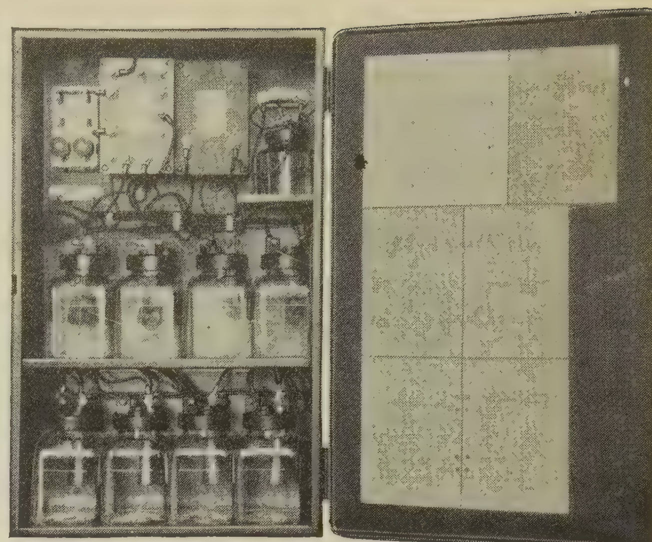

Balkite Telephone Charger—Model CM

A new heavy duty Balkite Charger

specially designed for the telephone board —totally unlike any now on the market

This charger is especially designed for telephone use and it embodies every improvement which actual use has shown to be desirable for telephone service. It contains the new noiseless Balkite telephone filter circuit which does not merely reduce noise, but eliminates it entirely.

The rate is 3 amperes, making it suitable for PBX and small central office boards. It will serve any 24 or 48 volt battery. It is the equivalent of a 10 ampere rectifier or motor generator set used for periodic charging.

This charger, like other Balkite Chargers, operates continuously on trickle charge, regardless of whether the board is in service or not. It reduces investment, frees cables otherwise used for charging, does away replacing batteries and periodic charging.

It is particularly desirable in hotels, office buildings, newspaper offices—wherever boards must be in continuous service.

Model CM is complete, encased in a steel cabinet, ready to install. Our engineers will be glad to give you both cost and savings figures on any installation you specify.

FANSTEEL PRODUCTS COMPANY, Inc., North Chicago, Ill.

FANSTEEL Balkite Battery Chargers

FANSTEEL PRODUCTS COMPANY, Inc., *North Chicago, Illinois*

Gentlemen: Please send me your bulletin TC-8 with complete information on Balkite Chargers, particularly CM.

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A. I. E. E.—6-28

The Thrust-Radial Electric Motors

Bearing durability is the critical factor in motor costs. Radical savings are certain with bearings which overcome not only the wear of friction and radial load, *but of thrust and shock as well.* That is exactly what Timken Bearings do, because they have the extreme thrust-radial capacity made possible only by Timken tapered construction, Timken *POSITIVELY ALIGNED ROLLS* and Timken electric steel.

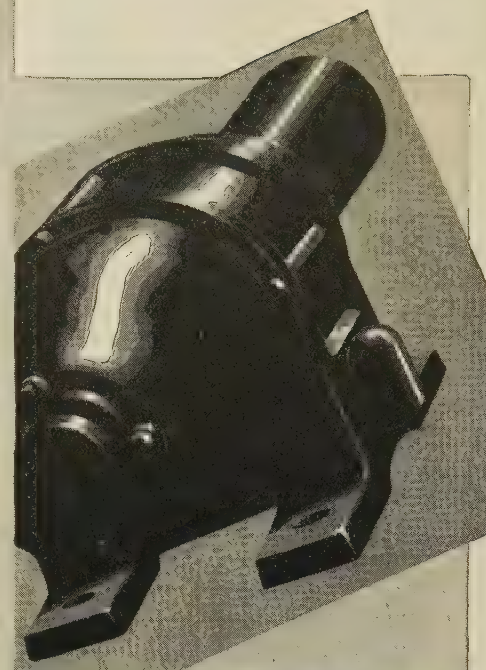
Full thrust-radial capacity means invincible endurance—the endurance which has brought all Industry to Timkens—which makes anti-friction economies practical for the million-pound loads of cement mills or steel mills—which preserves the micrometer accuracy of machine tool spindles—which is speeding output and slashing depreciation charges in every type of industrial equipment.

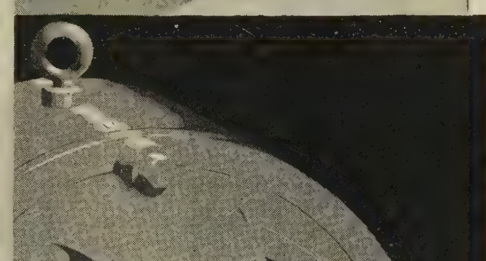
Timken thrust-radial capacity in motors makes them equally efficient operating on floor, wall or ceiling. It makes them equally wear-proof with any type of drive. It permits the compact mountings that save space, shorten shafts, increase rigidity and improve ventilation.

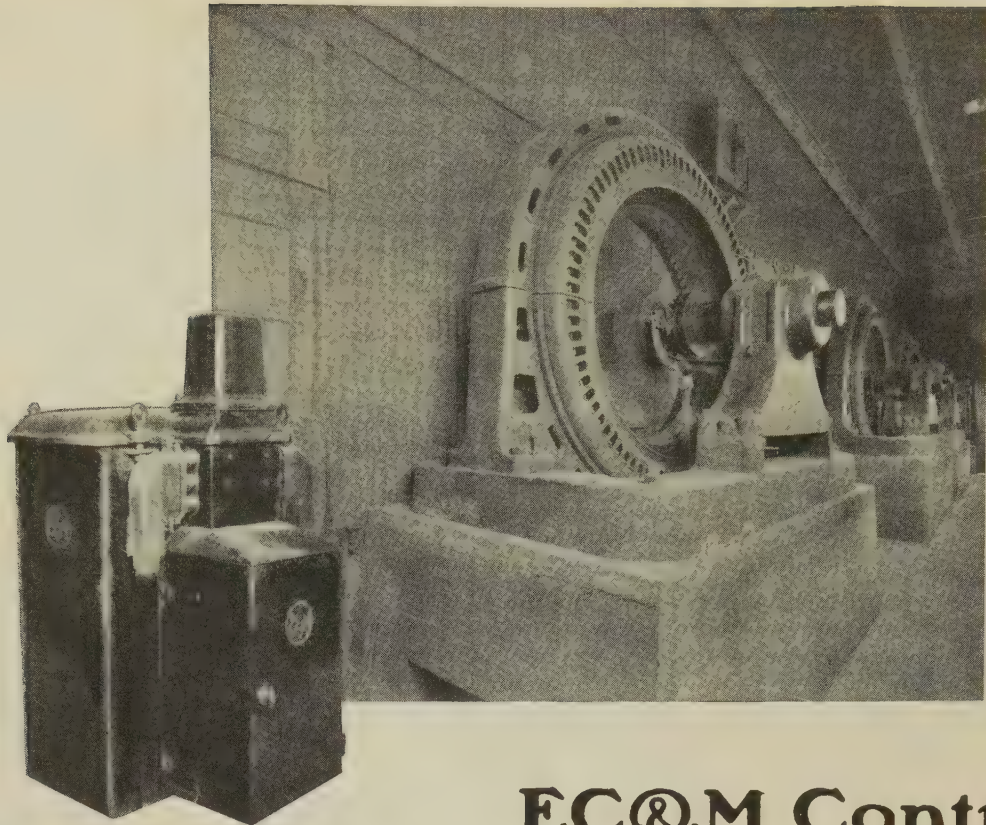
With nothing more than a negligible amount of lubrication Timken-equipped motors are kept like new. Abrasion and burn-outs are warded off permanently. There is no leakage or dripping to soak the windings or damage the product. And acceleration is faster, but non-destructive.

Timken Bearings are forcing costs to their lowest levels in motors, as in practically every type of equipment throughout all Industry. The records of thousands of Timken-equipped motors are conclusive. Specify Timken Bearings for the heavy duty jobs that once were "death to motors." Specify Timken Bearings for any motor you order. Any motor manufacturer will build them in for you.

THE TIMKEN ROLLER BEARING CO., CANTON, OHIO







EC&M Control operates these synchronous motors

Any of these 500 HP, 2300 volt synchronous motors can be started up as intelligently by a mill hand as by a trained electrician. Either man has only to throw a master switch and an EC&M Automatic Synchronous Motor Starter does the thinking on this usually complicated job. The switching operations necessary to bring the motor to synchronism are handled automatically by the Starter without any attention from the operator.

All of the mechanism of an EC&M Synchronous Motor Starter is contained in a single unit. The main switching contacts open and close under oil contained in a welded boiler plate tank, while the field switching mechanism is mounted in a dust-proof cabinet attached to the tank. The overload-protective equipment is enclosed in the dust-proof hood of the Starter.

EC&M Synchronous Motor Starters can be supplied for motors of any voltage up to 2300 volts, for slow or high speed motors and for full voltage or reduced voltage starting. EC&M Automatic Power Factor Regulators can be supplied to work with EC&M Synchronous Motor Starters.

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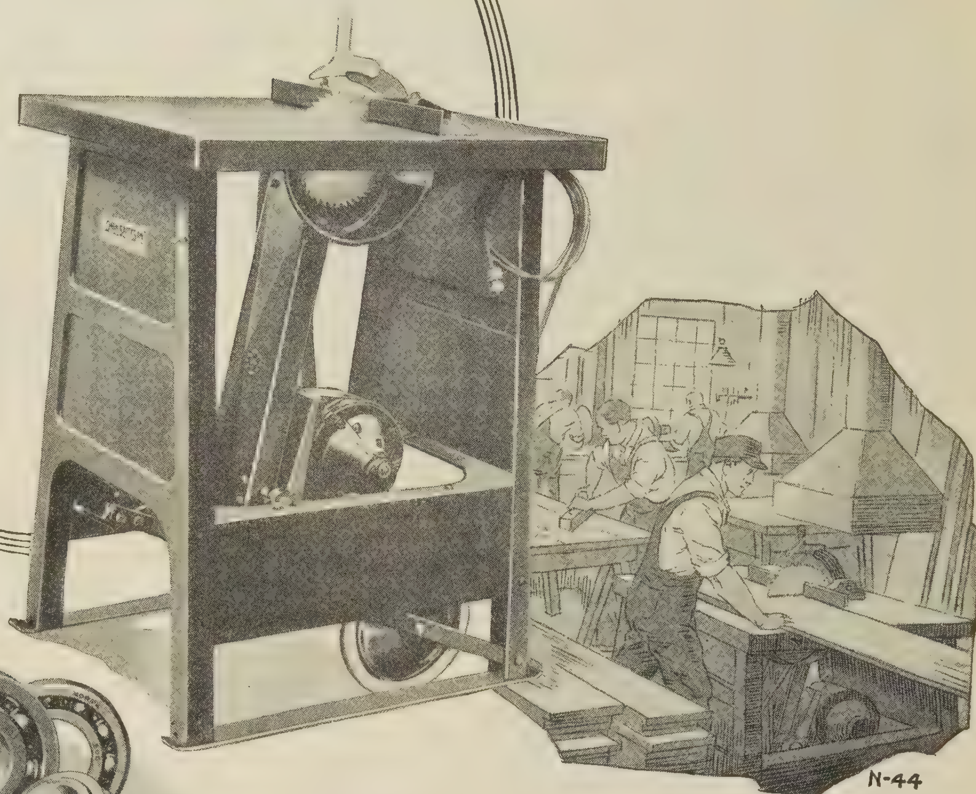
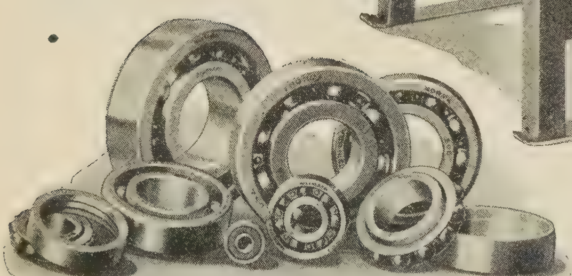
Where Production Must Not Fail

D. W. Onan & Sons, Chicago—speaking of the "NORMA" Precision Ball Bearings used in their "Onan Safety Saw"—say, "we have yet to find one instance of a failure. This is a wonderful record—and the uniformity of these bearings greatly helps in our production."





The "NORMA" Bearings in the "Onan Safety Saw" arbor, run at 5250 R. P. M., under heavy crowding saw cuts. But this is only a moderate speed for "NORMAS"—which are successfully operating up to 50,000 R. P. M.

THE sturdy design, uniform quality, and high precision of "NORMA" Ball Bearings combine to give a high factor of safety which engineers and manufacturers in ever-increasing number are relying upon in machines built for maximum production at minimum cost.

NORMA-HOFFMANN BEARINGS CORPORATION

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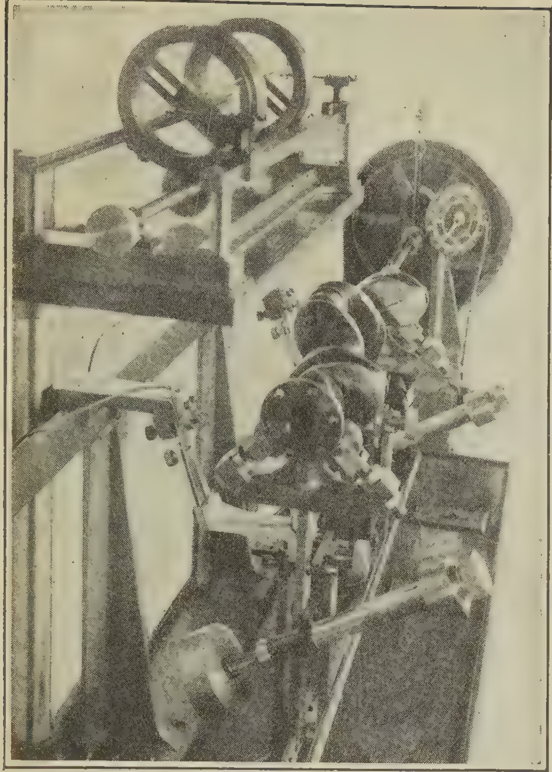
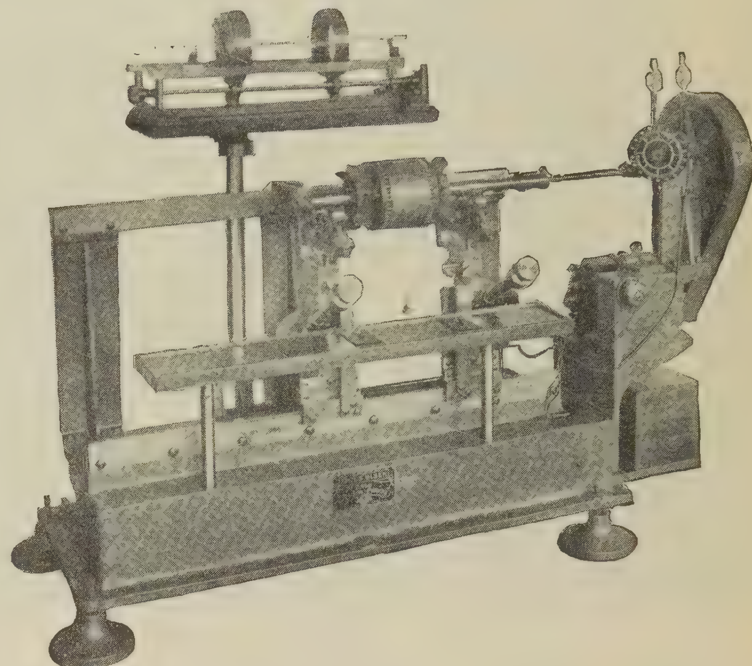
NB-909

"NORMA"

PRECISION BALL BEARINGS



Here's a newer, faster way—



to test rotating parts *for Balance*

This amazing new machine—the Olsen-Lundgren Centrifugal High Tension Spark type of Balancing Machine balances rotating objects in an incredibly short time because:

1. *It indicates* (on a dial) the angle of unbalance at both ends almost instantaneously.
2. *Indicates* (at a glance) whether rotor has plain static, dynamic, or combined static and dynamic unbalance.
3. Either end of the part can be balanced at will without turning end for end.
4. *Indicates amount* of unbalance.
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6. An unskilled workman can be taught to operate it in 15 minutes.

A special bulletin describes the exact operation. Get it—for *the last word* in balancing.

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TESTING MACHINE COMPANY

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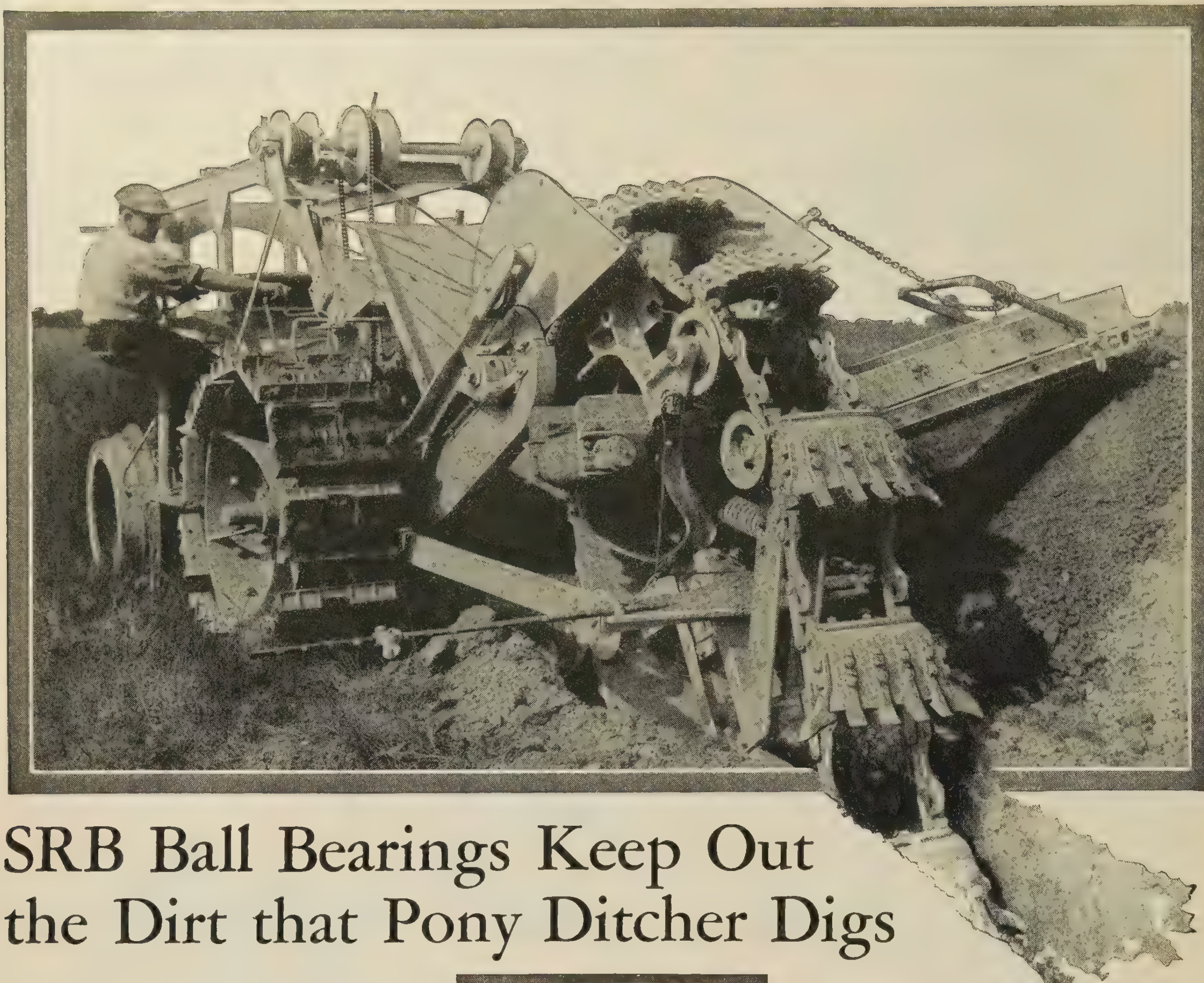
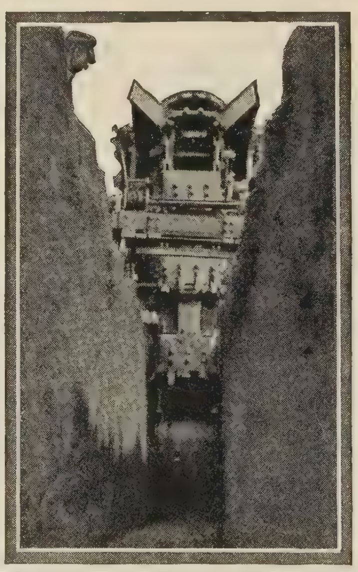


SRB Ball Bearings Keep Out the Dirt that Pony Ditcher Digs

TOPPING Pony Ditcher's lifetime job is digging dirt and muck mixed with gravel, grit, sand, and mud, but—

It won't let that same dirt dig at its vital friction points. These are protected with the New Type SRB Ball Bearing that keeps dirt out—keeps oil in all the time it is providing anti-friction. So complete is the protection against even the finest grains of flying dust



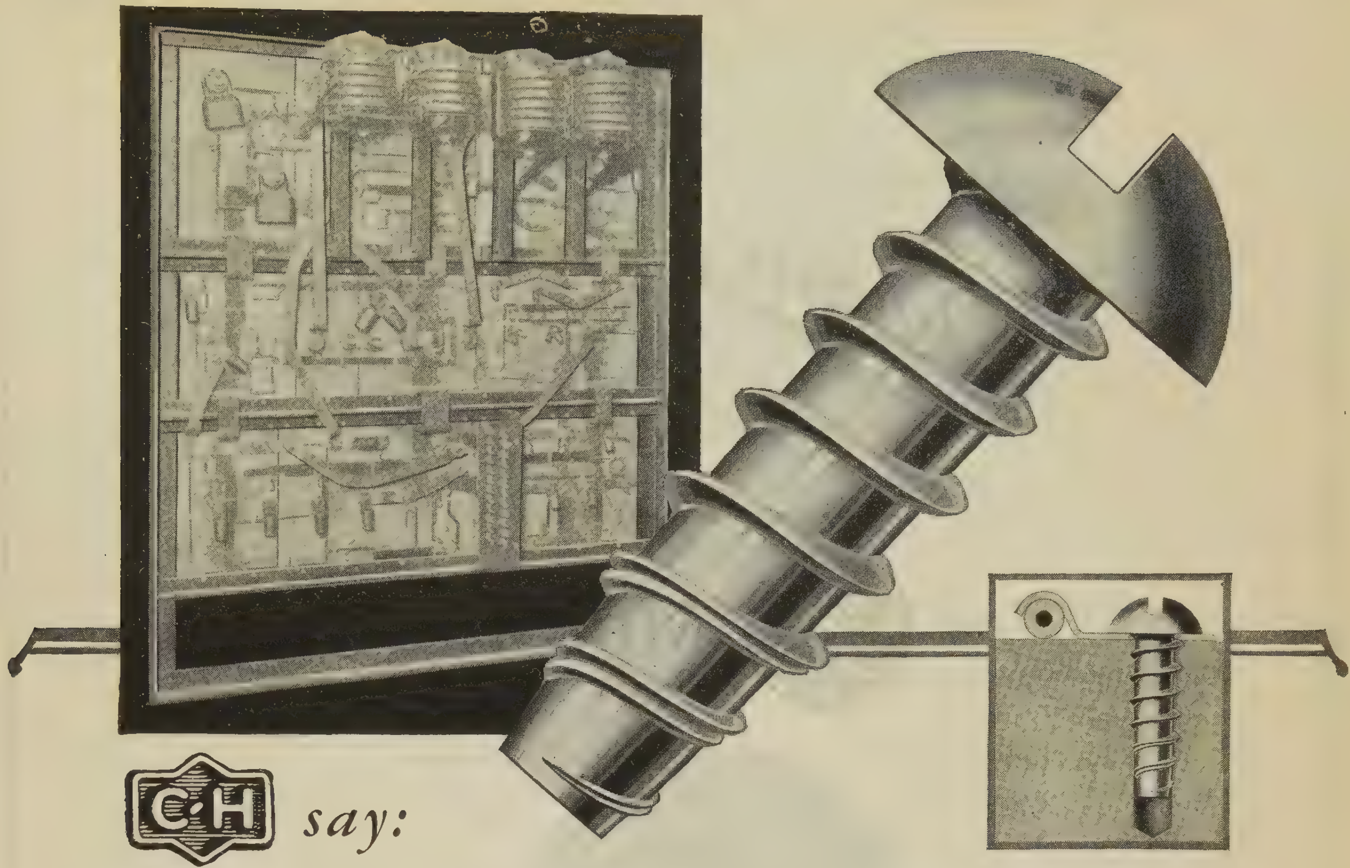
that the Pony Ditcher can dirty itself as much as it likes without worry about grit getting in, or oil leaking out.

Your machine may have a cleaner job, but if it works at any kind of task where dust or dirt flies and enters friction parts, write us for information on the new protective SRB Ball Bearing that acts like a dust-proof wall.

STANDARD STEEL AND BEARINGS INCORPORATED

Plainville *Connecticut*

Ball SRB Bearings



C-H say:

"It insures a permanently tight job under all conditions!"

THE Cutler-Hammer Mfg. Co. used escutcheon pins for fastening wiring cleats to their switchboard panels but were not satisfied because the cleats worked loose. They then adopted Parker-Kalon Type "Z" Hardened Self-tapping Sheet Metal Screws for the purpose. Now, they obtain fastenings that meet every demand for strength and ability to hold the cleats firmly in place. "A permanently tight job under all conditions" reads their endorsement.

Many other switchboard manufacturers and central stations have adopted these remarkable Screws in place of expansion bolts, lead anchors, plugs, etc., because they are easier to use, make better fastenings and preclude the possibility of marring or cracking the material, as a result of too heavy a blow or a slip of the hammer.

Parker-Kalon Self-tapping Screws are so threaded and hardened that they cut their own thread in the material, like a tap, as they are turned in with a screw driver. They can be removed when necessary and replaced in the same holes without impairing the strength of the fastening.

In addition to providing a better, easier, cheaper method of making fastenings to slate, ebony asbestos, Bakelite, etc., these Screws are used with similarly advantageous results for assembling aluminum and die castings and for joining and making fastenings to sheet metal. Tapping, with its breakage of taps and expensive tapping machinery is eliminated.

Use the coupon to obtain samples for test. No cost—no obligation.

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Please send me a handful of Type "Z" Hardened Self-tapping Screws. I want to try them out for

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Sheet Metal Screws

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Direct Connected to

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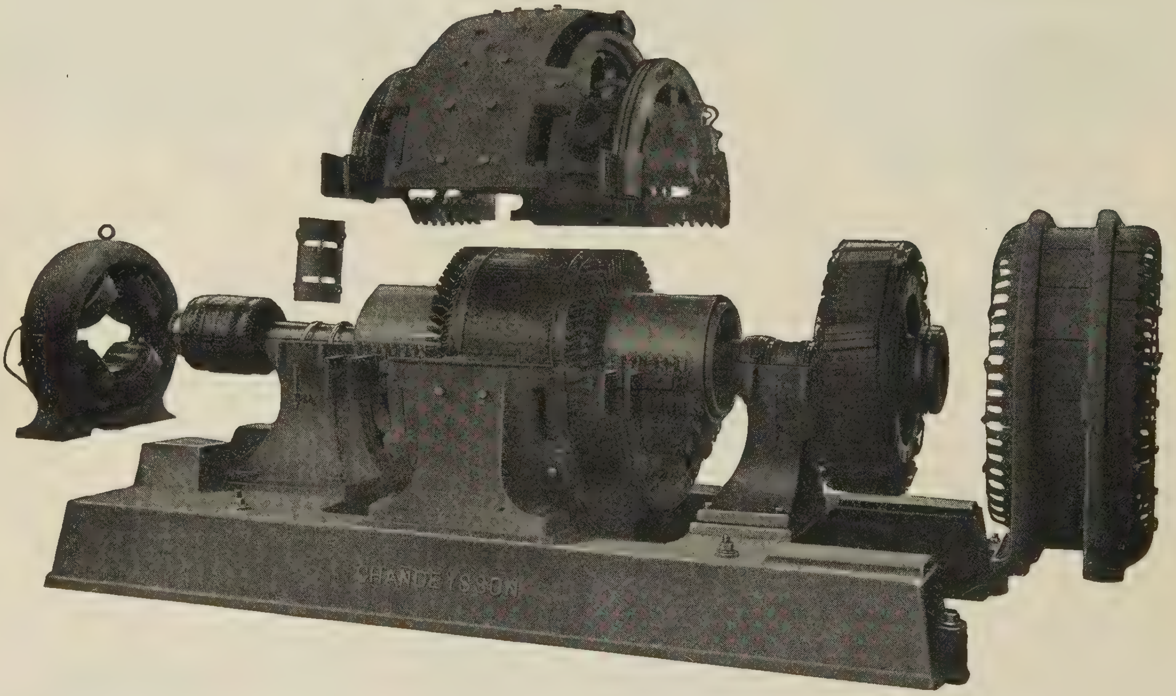

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OVERHUNG SYNCHRONOUS MOTOR AND EXCITER

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5,000 AMPERE 5″x13″ 15,000 AMPERE 8″x20″

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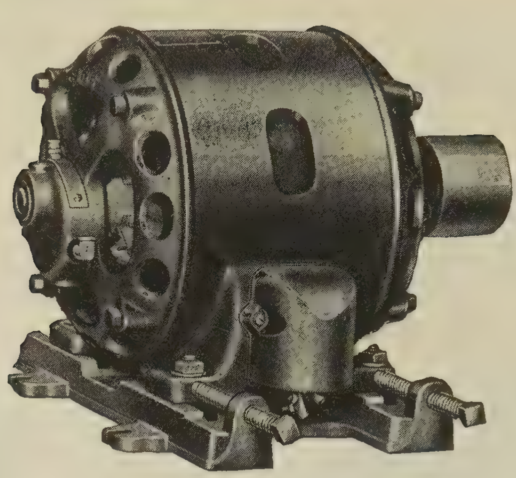
CHANDEYSSON ELECTRIC CO., St. Louis, U. S. A.



1 Horse Power Century Type RS
Repulsion Start Induction Single Phase Motor

For Electric Refrigerators Oil Burners and House Pumps

The ability of Century Type RS Repulsion Start Induction Single Phase Motors to continuously meet all of the service and power supply requirements of such installations as electric refrigerators, oil burners and house pumps, makes them the logical choice for these and other installations, especially where high starting torque and low starting current are desirable.

At least one year's continuous 24-hour-per-day operation, without reoiling, is assured by the Century Wool-yarn System of Lubrication. This is standard for 1 horse power and smaller motors.

They operate quietly. Static and running balance tests are applied to each armature, eliminating vibration to the greatest degree commercially practical.... Bearings are long lived. They are machined from phosphor bronze castings, the highest grade bearing material obtainable . . . . Ball bearings can be furnished when needed .... Brushes and commutators last. Brushes touch the commutator only during the starting period, about 1/900th part of the time the motor is operating.

Built in standard sizes from 1/8 to 40 horse power.

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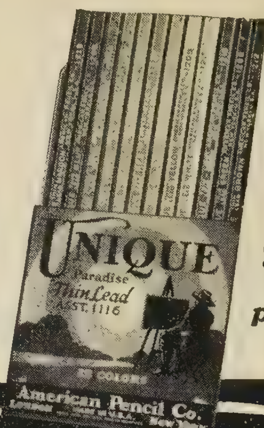

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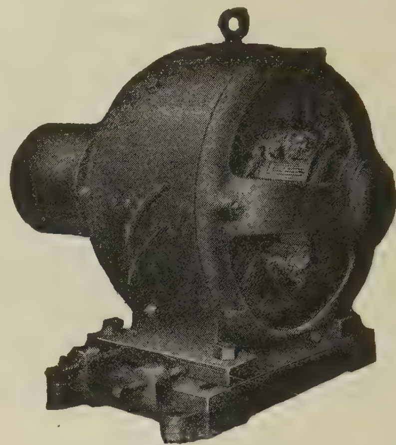

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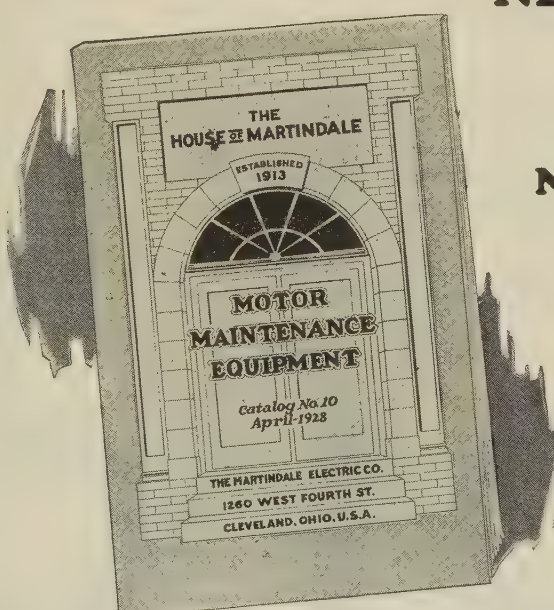

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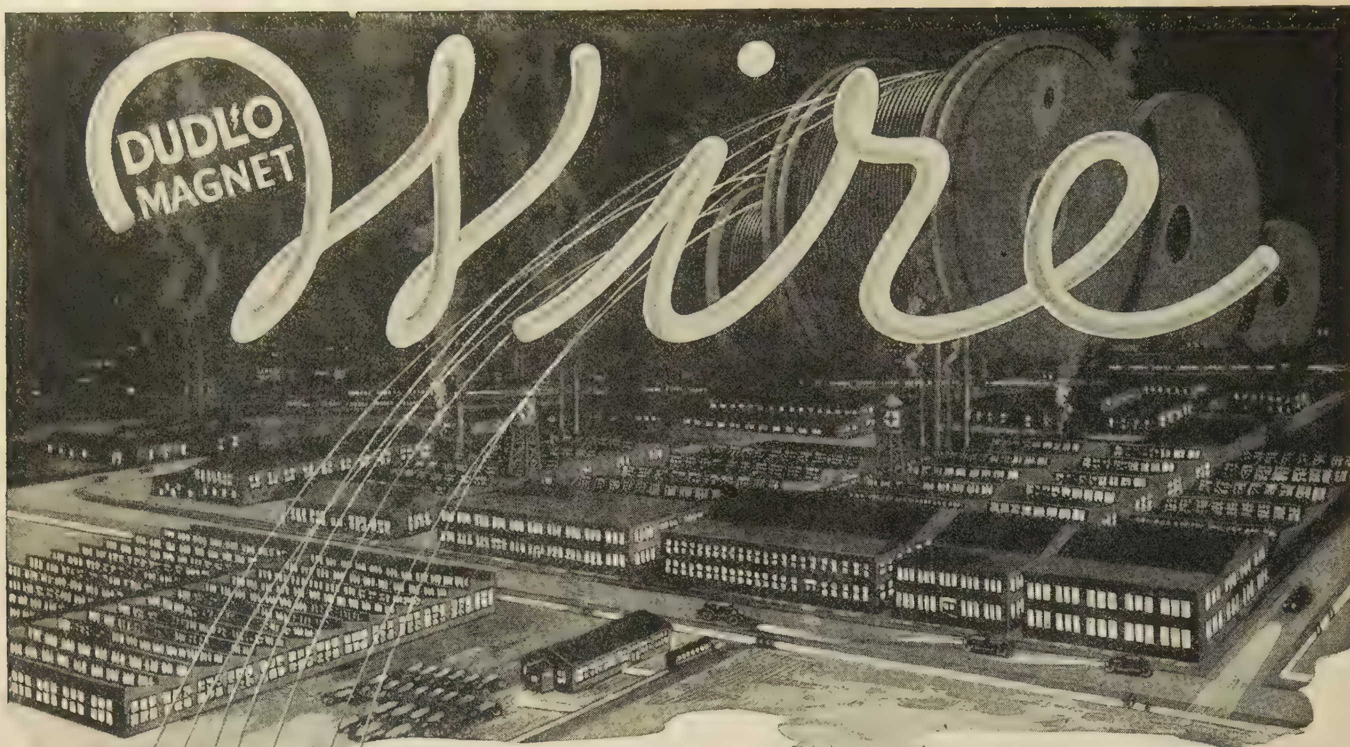

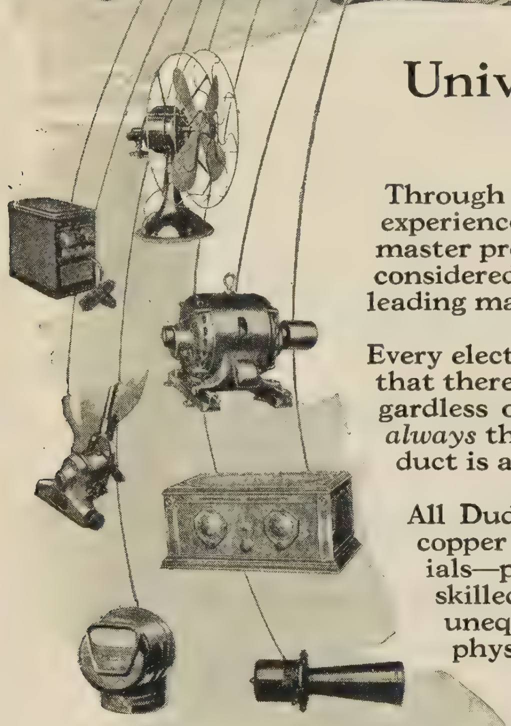

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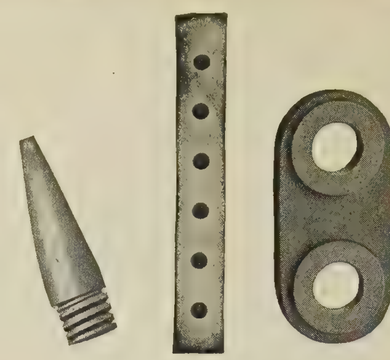

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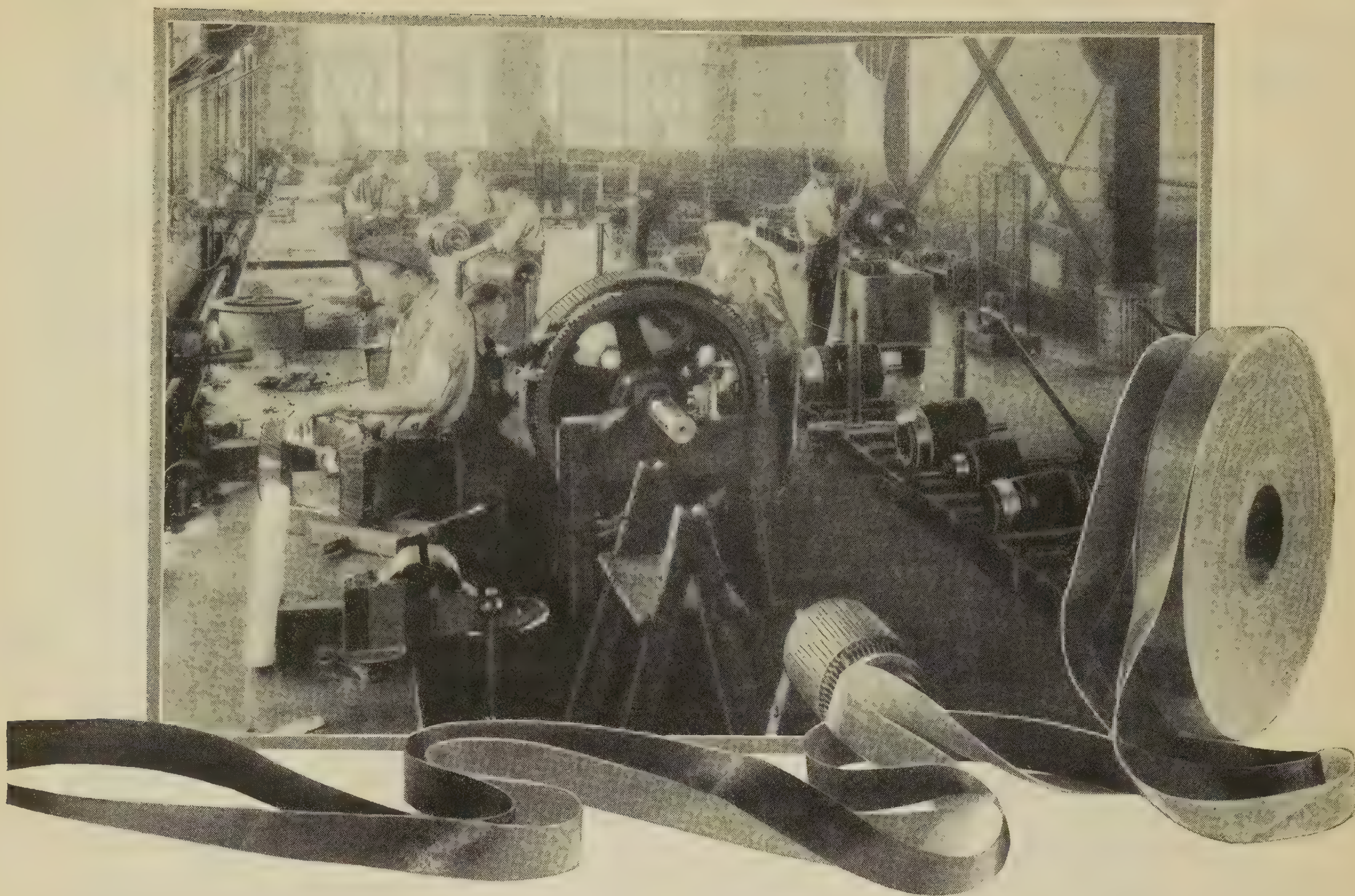

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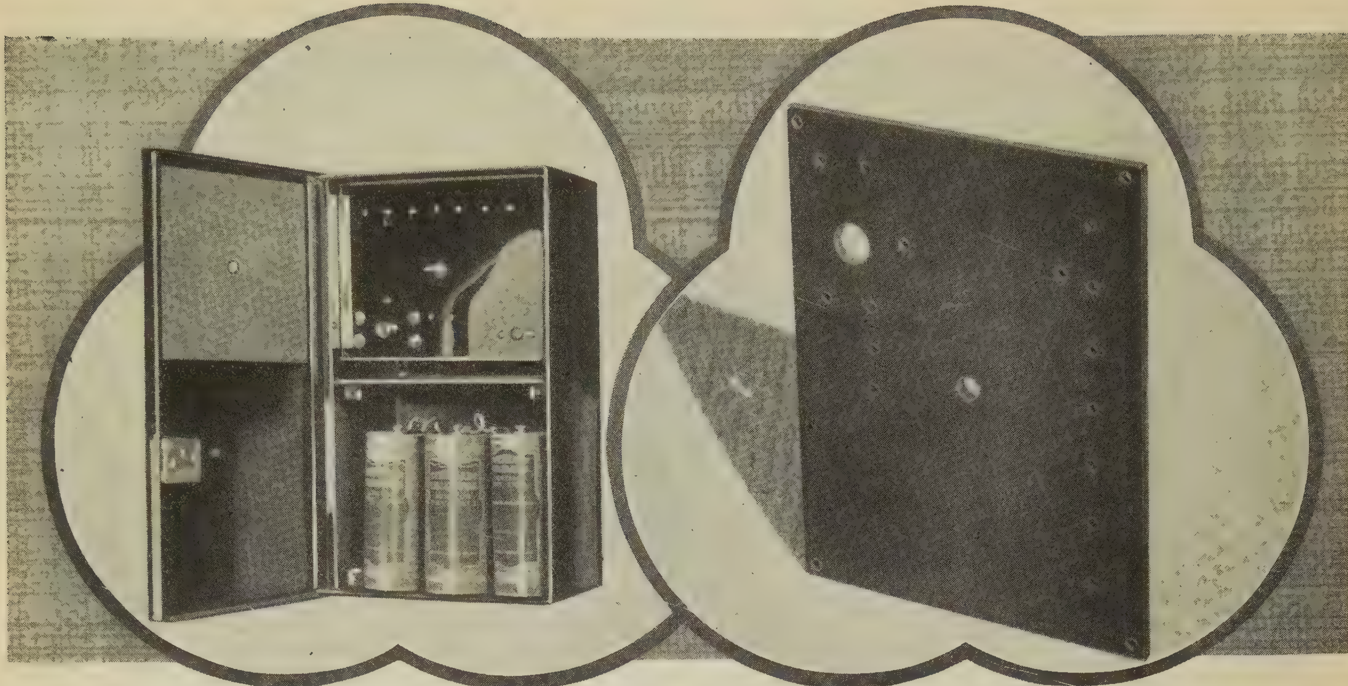

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HEAVY ¾-inch slate was formerly used for this Burglar Alarm control panel. These slate panels were frequently chipped or cracked in drilling, and were often streaked with foreign materials of low resistance causing leaking between terminals.

Substituting Bakelite Laminated for slate produced astonishing economies and advantages. Each slate panel had to be drilled separately but three of the 3/16-inch Bakelite Laminated are drilled at one time—eliminating forty-eight drilling operations. A total saving of more than 50% in labor and tools was effected.

In addition, the leakage between current carrying parts was minimized, a more sensitive adjustment of the instruments made possible, and the use of smaller, lighter weight cabinets made practical. All of these advantages far more than offset the higher cost of the Bakelite Laminated Panel.

Bakelite Engineering Service

Intimate knowledge of thousands of varied applications of Bakelite Materials combined with eighteen years' experience in the development of phenol resinoids for electrical uses provides a valuable background for the cooperation offered by our engineers and research laboratories. Write for Booklet No. 3, "Bakelite Molded."

BAKELITE CORPORATION

247 Park Avenue, New York, N. Y. Chicago Office, 635 West 22nd Street

BAKELITE CORPORATION OF CANADA, LTD., 163 Dufferin Street, Toronto, Ont.

BAKELITE

REGISTERED U. S. PAT. OFF.

THE MATERIAL OF A THOUSAND USES

"The registered Trade Mark and Symbol shown above may be used only on products made from materials manufactured by Bakelite Corporation Under the capital "B" is the numerical sign for infinity, or unlimited quantity It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."

Classified Advertiser's Index for Buyers—*Continued*

FUSES—*Continued*
Enclosed Non-Refillable
Chicago-Jefferson Fuse & Elec. Co., Chicago
General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Open Link
Chicago-Jefferson Fuse & Elec. Co., Chicago
General Electric Co., Schenectady
Metropolitan Device Corp., Brooklyn, N. Y.
Western Electric Co., All Principal Cities
High Tension
Delta-Star Electric Co., Chicago
Metropolitan Device Corp., Brooklyn, N. Y.
Western Electric Co., All Principal Cities
FUSE PULLERS
Kearney Corp., Jas. R., St. Louis
GEARS, FIBRE
General Electric Co., Schenectady
GENERATORS AND MOTORS
Acme Electric & Mfg. Co., The, Cleveland
Allis-Chalmers Mfg. Co., Milwaukee
Burke Electric Co., Erie, Pa.
Century Electric Co., St. Louis
Chandeysson Electric Co., St. Louis
Electric Specialty Co., Stamford, Conn.
Electro-Dynamic Co., Bayonne, N. J.
General Electric Co., Schenectady
Lincoln Electric Co., The, Cleveland
Wagner Electric Corp., St. Louis
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
GENERATING STATION EQUIPMENT
Allis-Chalmers Mfg. Co., Milwaukee
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
GROUND CONNECTIONS
Hubbard & Co., Pittsburgh
GROUND RODS
Copperweld Steel Co., Glassport, Pa.
Hubbard & Co., Pittsburgh
Western Electric Co., All Principal Cities
HARDWARE, POLE LINE AND INSULATOR
Hubbard & Co., Pittsburgh
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
HEADLIGHTS
Ohio Brass Co., Mansfield, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
HEATERS, INDUSTRIAL
General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
IGNITION SYSTEMS, AUTOMOBILE
Wagner Electric Corp., St. Louis
INDICATORS, SPEED
Roller-Smith Co., New York
INDICATORS, REMOTE, WATER LEVEL
Cramer & Co., Inc., R. W., New York
INSTRUMENTS, ELECTRICAL
Graphic
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Indicating
Burt, Dr. Robert C., Pasadena
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Jewell Elec. Instrument Co., Chicago
Roller-Smith Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Weston Elec. Inst. Corp., Newark, N. J.
Integrating
Duncan Elec. Mfg. Co., Lafayette, Ind.
Ferranti, Ltd., Hollinwood, England
Ferranti, Inc., New York
Ferranti Electric, Ltd., Toronto, Ont.
General Electric Co., Schenectady
Roller-Smith Co., New York
Sangamo Elec. Co., Springfield, Ill.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Radio
General Radio Co., Cambridge, Mass.
Jewell Elec. Instrument Co., Chicago
Repairing and Testing
Electrical Testing Laboratories, New York
Jewell Elec. Instrument Co., Chicago
Martindale Electric Co., The, Cleveland
Scientific Laboratory, Testing
Burt, Dr. Robert C., Pasadena
General Electric Co., Schenectady
Jewell Elec. Instrument Co., Chicago
Martindale Electric Co., The, Cleveland
Metropolitan Device Corp., Brooklyn, N. Y.
Roller-Smith Co., New York
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Weston Elec. Inst. Corp., Newark, N. J.
Telegraph
Western Electric Co., All Principal Cities

INSULATING MATERIALS
Beads, Insulating
Martindale Electric Co., The, Cleveland
Board
General Electric Co., Bridgeport, Conn.
West Va. Pulp & Paper Co., New York
Cloth
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Composition
American Lava Corp., Chattanooga
Bakelite Corporation, New York
Belden Mfg. Co., Chicago
General Electric Co., Bridgeport, Conn.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Compounds
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Standard Underground Cable Co., Pittsburgh
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Fibre
Belden Mfg. Co., Chicago
General Electric Co., Bridgeport, Conn.
West Va. Pulp & Paper Co., New York
Isolantite
Isolantite Co. of America, New York
Lava
American Lava Corp., Chattanooga, Tenn.
Mica
Chicago Mica Co., Valparaiso, Ind.
Mica Insulator Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Paper
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Silk
General Electric Co., Bridgeport, Conn.
Tape
Belden Mfg. Co., Chicago
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Okonite Co., The, Passaic, N. J.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Varnishes
General Electric Co., Bridgeport, Conn.
Mica Insulator Co., New York
Minerallac Electric Co., Chicago
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
INSULATORS, HIGH TENSION
Composition
General Electric Co., Schenectady
Glass
Hemingray Glass Co., Muncie, Ind.
Porcelain
Canadian Porcelain Co., Ltd., Hamilton, Ont.
General Electric Co., Schenectady
Lapp Insulator Co., Inc., LeRoy, N. Y.
Locke Insulator Corp., Baltimore
Ohio Brass Co., Mansfield, O.
Thomas & Sons Co., R., Lisbon, O.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Post Type
Delta-Star Electric Co., Chicago
Ohio Brass Co., Mansfield, O.
INSULATORS, TELEPHONE & TELEGRAPH
Hemingray Glass Co., Muncie, Ind.
Ohio Brass Co., Mansfield, O.
Western Electric Co., All Principal Cities
INSULATOR PINS
Hubbard & Co., Pittsburgh
Ohio Brass Co., Mansfield, O.
Thomas & Sons Co., R., Lisbon, O.
ISOLANTITE
Isolantite Co. of America, New York
LAMP GUARDS
Matthews Corp., W. N., St. Louis
Western Electric Co., All Principal Cities
LAVA
American Lava Corp., Chattanooga
LIGHTNING ARRESTERS
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Hubbard & Co., Pittsburgh
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
LOCOMOTIVES, ELECTRIC
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
LUBRICANTS
Texas Co., The, New York
MAGNETIC SEPARATORS
Electric Controller & Mfg. Co., Cleveland

METERS, ELECTRICAL
(See INSTRUMENTS ELECTRICAL)
METER SEALS
Metropolitan Device Corp., Brooklyn, N. Y.
MICA PRODUCTS
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
MICA UNDERCUTTERS
Martindale Electric Co., The, Cleveland
MOLDED INSULATION
Bakelite Corporation, New York
Belden Mfg. Co., Chicago
Burke Electric Co., Erie, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
MOLYBDENUM
Fansteel Products Co., Inc., North Chicago
MOTORS
(See GENERATORS AND MOTORS)
OHMMETERS
Jewell Elec. Instrument Co., Chicago
Martindale Elec. Co., Cleveland
Roller-Smith Co., New York
Weston Elec. Instr. Corp., Newark, N. J.
OIL SEPARATORS & PURIFIERS
Sharples Specialty Co., The, Philadelphia
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
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Burt, Dr. Robert C., Pasadena
PANEL BOARDS
(See SWITCHBOARDS)
PATENT ATTORNEYS
(See PROFESSIONAL ENGINEERING DIRECTORY)
PHOTO-ELECTRIC CELLS
Burt, Dr. Robert C., Pasadena
PLATING GENERATORS
Burke Electric Co., Erie, Pa.
Chandeysson Elec. Co., St. Louis
Electric Specialty Co., Stamford, Conn.
PLUGS
Delta-Star Electric Co., Chicago
General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
POLE LINE HARDWARE
Hubbard & Co., Pittsburgh
POLES, STEEL
Western Electric Co., All Principal Cities
POLES—TIES, WOOD
Western Electric Co., All Principal Cities
POTHEADS
G & W Electric Specialty Co., Chicago
Ohio Brass Co., Mansfield, O.
Standard Underground Cable Co., Pittsburgh
Western Electric Co., All Principal Cities
PRINTING TELEGRAPH SYSTEMS
Stock Quotation Telegraph Co., New York
PROTECTIVE DEVICES
Metropolitan Device Corp., Brooklyn, N. Y.
Western Electric Co., All Principal Cities
PULLERS, SLACK
Matthews Corp., W. N., St. Louis
PUMPS
Allis-Chalmers Mfg. Co., Milwaukee
RADIO LABORATORY APPARATUS
General Radio Co., Cambridge, Mass.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
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Amrad Corp., Medford Hillside, Mass.
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General Electric Co., Schenectady
Ohio Brass Co., Mansfield, O.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
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Metropolitan Device Corp., Brooklyn, N. Y.
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Fansteel Products Co., Inc., North Chicago
General Electric Co., Schenectady
Wagner Electric Corp., St. Louis
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
REELS, PAYOUT AND TAKEUP
Matthews Corp., W. N., St. Louis
REGULATORS, VOLTAGE
Burke Electric Co., Erie, Pa.
General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
RELAYS
Cramer & Co., Inc., R. W., New York
Electric Controller & Mfg. Co., Cleveland
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
RESISTOR UNITS
General Electric Co., Schenectady
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
RHEOSTATS
General Electric Co., Schenectady
Sundh Electric Co., Newark, N. J.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

A home town enterprise backed by national experience

An Advertisement of the
American Telephone and Telegraph Company

THE Bell System is a home town enterprise in operation so that each community may have service that suits its needs. It is a national enterprise in research, engineering and manufacture so that every telephone user may have the best that concentration and quantity production can achieve.

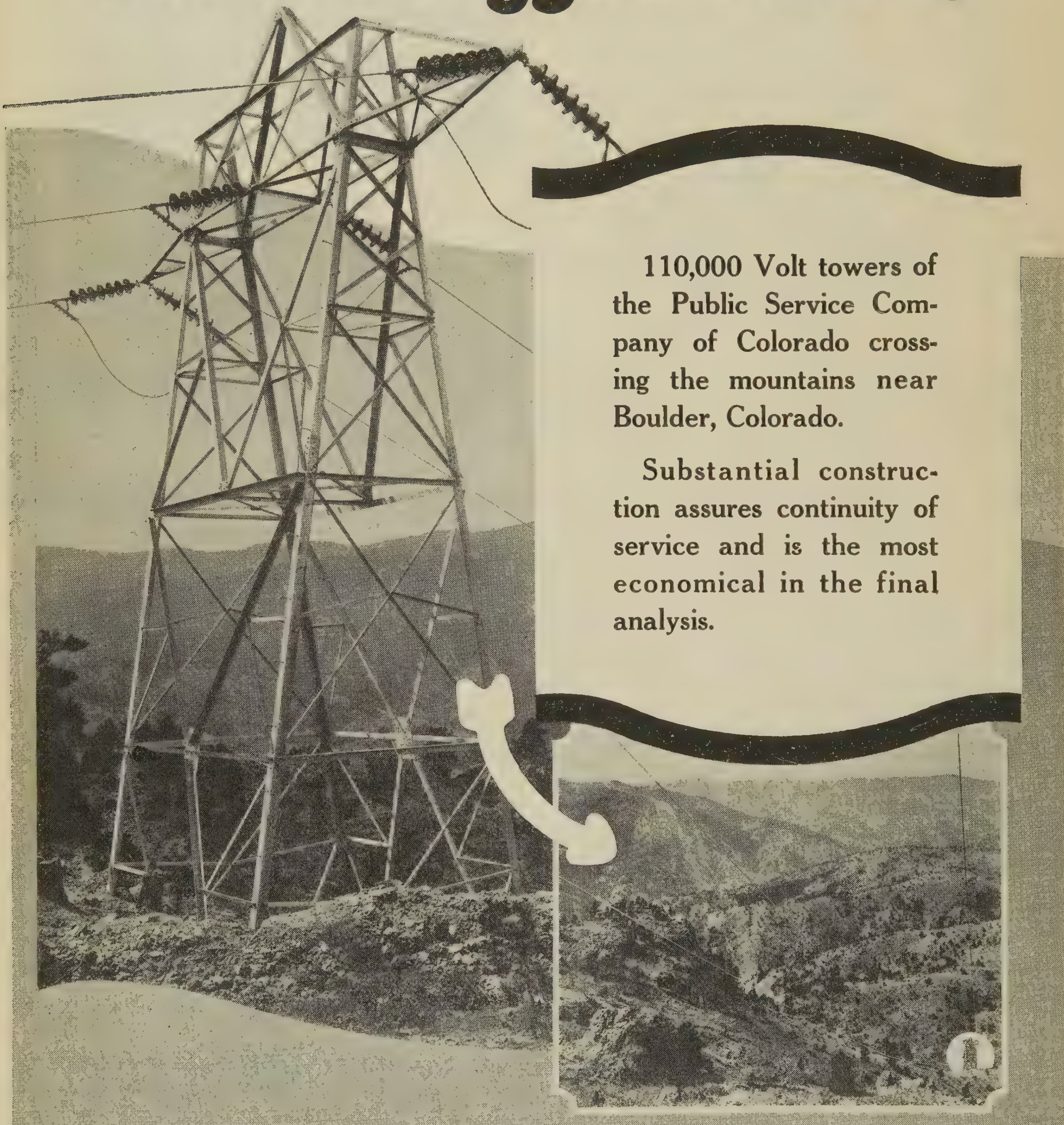
There are twenty-four operating companies devoting their energies to telephone problems throughout the United States—for example, the Northwestern Bell Telephone Company operating throughout Iowa, Minnesota, Nebraska, North Dakota and South Dakota. It has 11,000 men and women—friends and neighbors of the other people in their towns—working to maintain in its territory the best standards in telephony now known. In New York, in the American Telephone and Telegraph Company and the Bell Laboratories, are 5000 persons, including scientists, engineers and consultants in management, engaged in inventing better apparatus, and discovering better ways to do things.

The Northwestern Company with its 11,000 employees has the use of all that this group of 5000 in New York discover and perfect.

Likewise the other twenty-three operating companies. They are regional organizations adapted to local conditions, but behind every telephone in city or hamlet is the national organization for the development of the telephone art.

Classified Advertiser's Index for Buyers—*Continued*

Transmission Towers
Used in Rugged Country



110,000 Volt towers of the Public Service Company of Colorado crossing the mountains near Boulder, Colorado.

Substantial construction assures continuity of service and is the most economical in the final analysis.

AMERICAN BRIDGE COMPANY
71 BROADWAY, NEW YORK CITY
TOWER DEPT., FRICK BLDG., PITTSBURGH, PA.

FIBREX Tree Wire
through the Palm Trees in Sunny California.

Not only in California, but wherever overhead lines run through trees, FIBREX should be used. It assures better service to the community and extra protection to linemen and public.

FIBREX Tree Wire spliced in at bare spots in the line helps maintain steady illumination by reducing the number of short circuits and swinging grounds. As a part of your line FIBREX will pay its cost many times over.

FIBREX is a rubber insulated wire protected by a layer of tape, a serving of tarred jute, non-metallic FIBREX "armor" and a wear-resisting weatherproof braid.

Every distribution engineer should know what FIBREX is. A short piece with full information will be sent promptly on request.

Facts about FIBREX "Armor"

It is non-inductive.
It will not rot.
It cannot rust.
Prevents short circuits and grounds.

We manufacture wires and cables insulated with rubber, paper and varnished cambric.

SIMPLEX WIRE & CABLE Co
MANUFACTURERS
201 DEVONSHIRE ST., BOSTON
BRANCH SALES OFFICES
NEW YORK, 1328 Broadway SAN FRANCISCO, 390 Fourth St.
CHICAGO, 15 S. Desplaines St. CLEVELAND, 2019 Union Trust Bldg.
JACKSONVILLE, 1010 Barnett Nat'l Bank Bldg.

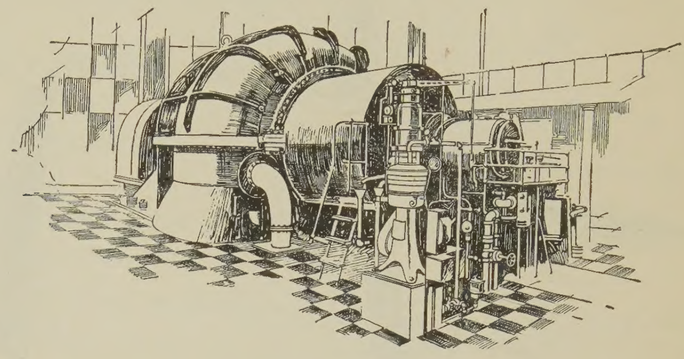
More detailed information with samples and quotations will be furnished on request.

ALPHABETICAL LIST OF ADVERTISERS

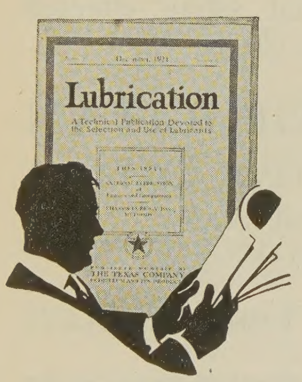
(For classified list of Advertisers see pages 60, 62 and 64)

On the Turbines

in Many of the Best Run Power Plants in the World



TEXACO REGAL OILS



The March 1928 issue of our magazine "Lubrication" contains a comprehensive treatment of the subject of Steam Turbine lubrication. Included is a list of steam turbines (by name of maker) with complete TEXACO recommendations for efficient lubrication.

Write to the address below for a free copy (specifying issue)—and ask to be pu on the free list to receive "Lubrication" monthly.

Steadily and surely, more and more turbine operators are coming to specify TEXACO REGAL OILS for the lubrication of their steam turbines.

These users know that TEXACO REGAL OILS ideally meet *every* turbine oil requirement.

TEXACO REGAL OILS are highly refined.

They counteract the oxidizing and acid forming effects of Heat and Air.

They do not emulsify with water.

They retard development of sludges due to the presence of dust and dirt.

They retard the catalyzing effects which metallic parts (especially copper and brass) involve in the formation of sludges.

TEXACO REGAL OILS for turbine lubrication are obtainable in four distinct ranges of Saybolt viscosity at 100° Fahr. so as to meet any turbine condition that could exist.

TEXACO REGAL OIL "A"—145 seconds
TEXACO REGAL OIL "B"—180 seconds
TEXACO REGAL OIL "C"—300 seconds
TEXACO REGAL OIL "E"—500 seconds

When you come to The Texas Company for steam turbine lubrication, you receive the benefit of a great oil company's resources and knowledge pertaining to the manufacture of *all* lubricants.

This will be readily apparent in the performance of any Turbine that is lubricated with TEXACO Regal Oils.

Equally valuable is the type of engineering service which TEXACO offers. Our Lubrication Engineers have had years of practical experience in turbine lubrication. Let them pool their knowledge and experience with your own operating requirements.

By just this combination—TEXACO REGAL OILS and TEXACO Lubrication Service — The Texas Company has brought about greater turbine efficiency in many of the best run power plants in the world.

THE TEXAS COMPANY

Texaco Petroleum Products

DEPT. W6, 17 BATTERY PLACE, NEW YORK CITY

OFFICES IN PRINCIPAL CITIES

Please mention the JOURNAL of the A. I. E. E. when writing to advertisers.


METROPOLITAN
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METROLATUM FILLED
HIGH TENSION
CABLE JOINT
A Manual of
Reactor Protection
METROPOLITAN
PROTECTIVE DEVICES
(MURRAY PATENTS)
CABLE RACKS
for
Overhead Distribution
METROPOLITAN DEVICE CORPORATION
1250 ATLANTIC AVENUE
BROOKLYN, NEW YORK
METROPOLITAN
Protective Devices
Cable Racks
METROPOLITAN
PROTECTIVE DEVICES
SUBWAY
SECTIONALIZING UNITS
EVERY DISTRIBUTION ENGINEER will find much to interest him in these booklets—for they contain data and charts showing "in service" experience and the economy and safety effected through the use of
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PROTECTIVE DEVICES
"MURRAY PATENTS"
SEND FOR THESE BOOKLETS
The only limit of service we can render you is the limit of our knowledge of your requirements.
METROPOLITAN
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1250 ATLANTIC AVENUE
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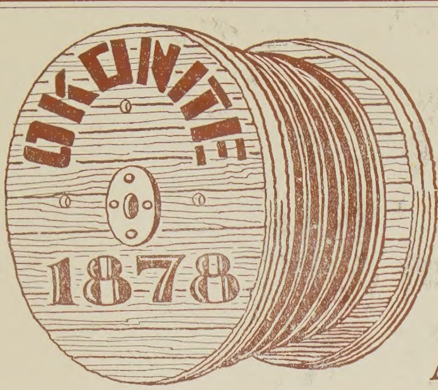
Since
1899



OKONITE QUALITY

A Standard Rigidly Maintained for Fifty Years

It is impossible to make the finest grade of rubber insulated wire and cable without:

1. The finest *quality* of crude rubber—the kind which naturally possesses greatest durability and toughness.
2. Combining this crude rubber in sufficient *quantity* with other carefully selected ingredients to obtain an insulating compound of desired long life and high electrical qualities.
3. *Application* of this compound by a method which assures perfect centering of the conductor and provides a wall of equal thickness all around.
4. Vulcanization of the compound by a method which prevents swelling of the rubber and provides a dense, homogeneous, non-porous insulation.

Quality

Nothing but wild Up-River fine Para Rubber is used in making Okonite Insulation. It is tougher and more lasting than any other form of rubber which could possibly be used.

Application

The compound, backed by tin, is *folded* around the conductor—an *exclusive* Okonite process which assures perfect centering of the conductor and an insulating wall of equal thickness all around.

Quantity

This rubber is combined with ingredients of such small bulk and high density that the rubber constitutes 30% of the compound by weight and 60% by volume—a quantity assuring longest life and highest insulating qualities.

Vulcanization

The tin backing forms a rigid mould which prevents the rubber from swelling during vulcanization. This is another exclusive process which provides greater density, longer life, greater tensile strength and improved electrical qualities.

THE OKONITE COMPANY

THE OKONITE-CALLENDER CABLE COMPANY, INC.

FACTORIES: PASSAIC, N. J. PATERSON, N. J.

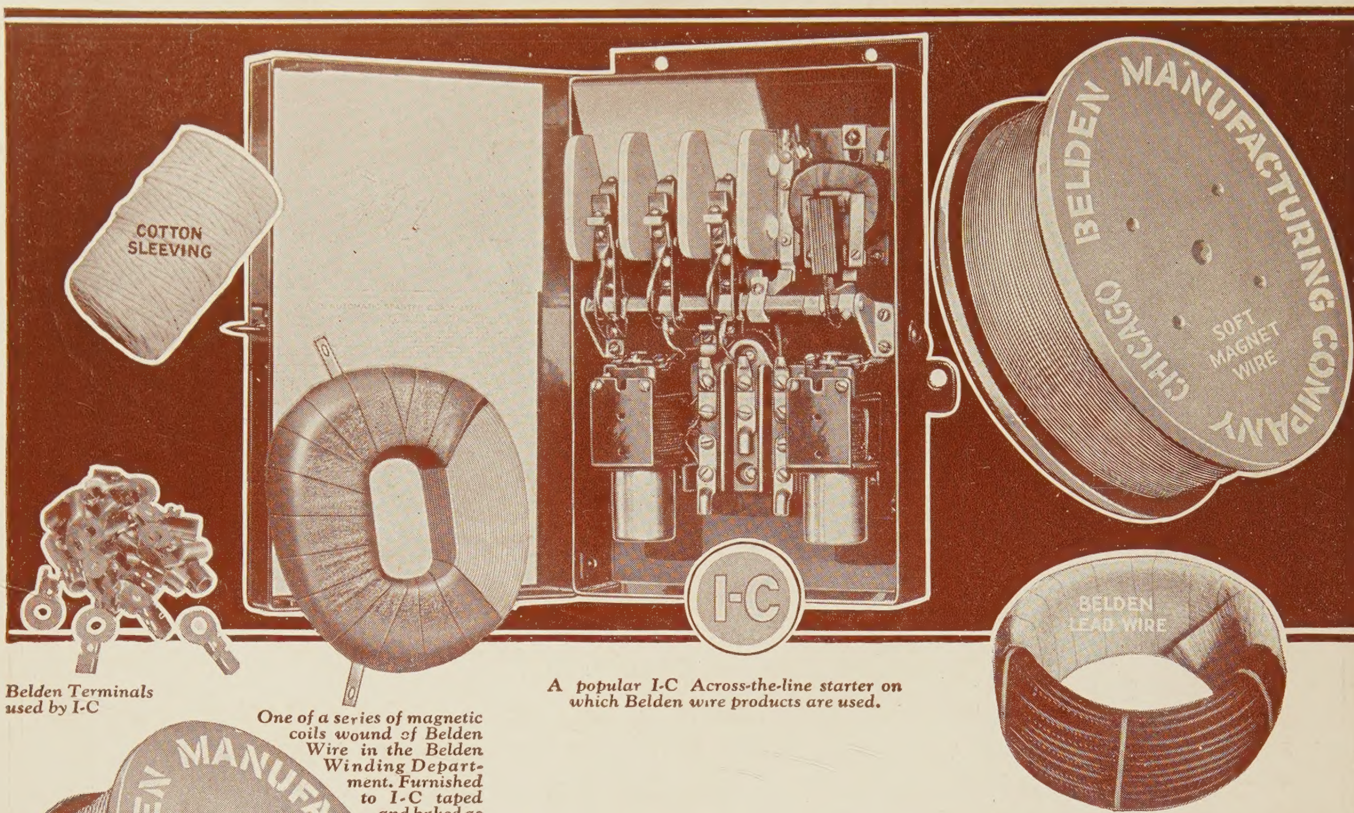
SALES OFFICES: NEW YORK . CHICAGO . PITTSBURGH . ST. LOUIS . ATLANTA
BIRMINGHAM . SAN FRANCISCO . LOS ANGELES . SEATTLE

General Electric Supply Corporation, Boston, Mass.

Novelty Electric Co., Philadelphia, Pa. F. D. Lawrence Electric Co., Cincinnati, O.

Canadian Representatives: Engineering Materials, Limited, Montreal

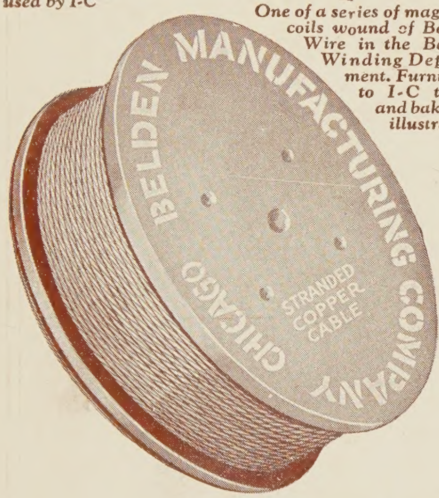
Cuban Representatives: Victor G. Mendoza Co., Havana



Belden Terminals used by I-C

One of a series of magnetic coils wound of Belden Wire in the Belden Winding Department. Furnished to I-C taped and baked as illustrated.

A popular I-C Across-the-line starter on which Belden wire products are used.



A Complete Wire Service for Industrial Controller Co.

"Specify Belden" is a *buy* word of the Industrial Controller Company that has consistently helped maintain the I-C reputation for reliability in their extensive line of electrical control apparatus.

Magnet Wire, Lead Wire—both Bare Stranded and Insulated, Coil Windings, Terminals, and Cotton Sleeving are a few of the Belden items they use in big quantities.

Industrial Controller Engineers appreciate the uniformly high quality of Belden Products. Their purchasing department finds the Belden Complete Wire Service both convenient and economical.

Standardize on Belden materials and secure these advantages for yourself. Utilize the extensive experience of the Belden Engineering Staff. It is yours for the asking.

Write for complete information.

Belden Manufacturing Company

2316-B South Western Avenue Chicago, Illinois

BELDEN PRODUCTS

Beldenamel and Textile Magnet Wire

Coil Windings

Beldenmold (Molded Bakelite Products)

Automotive Wires and Cables

Airplane Assemblies

Radio Wires, Cords and Cables

Rubber Covered Wires

Armored Cables

Flexible Armature Wires

Motor Lead Wires

Braided and Stranded Copper Cables

Cotton Sleeving

Specify Belden